Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR22**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

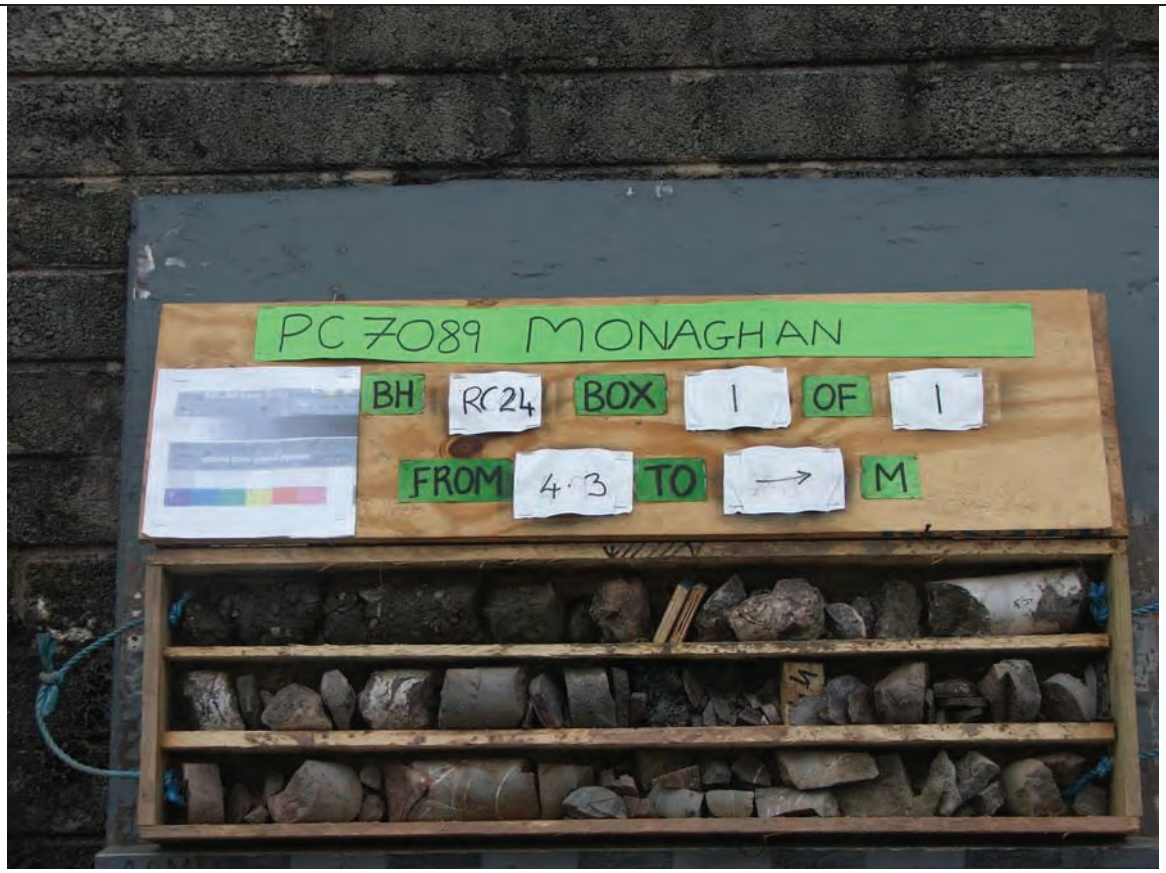
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR23**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR24**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR25**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR25**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR26**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR27**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR28**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

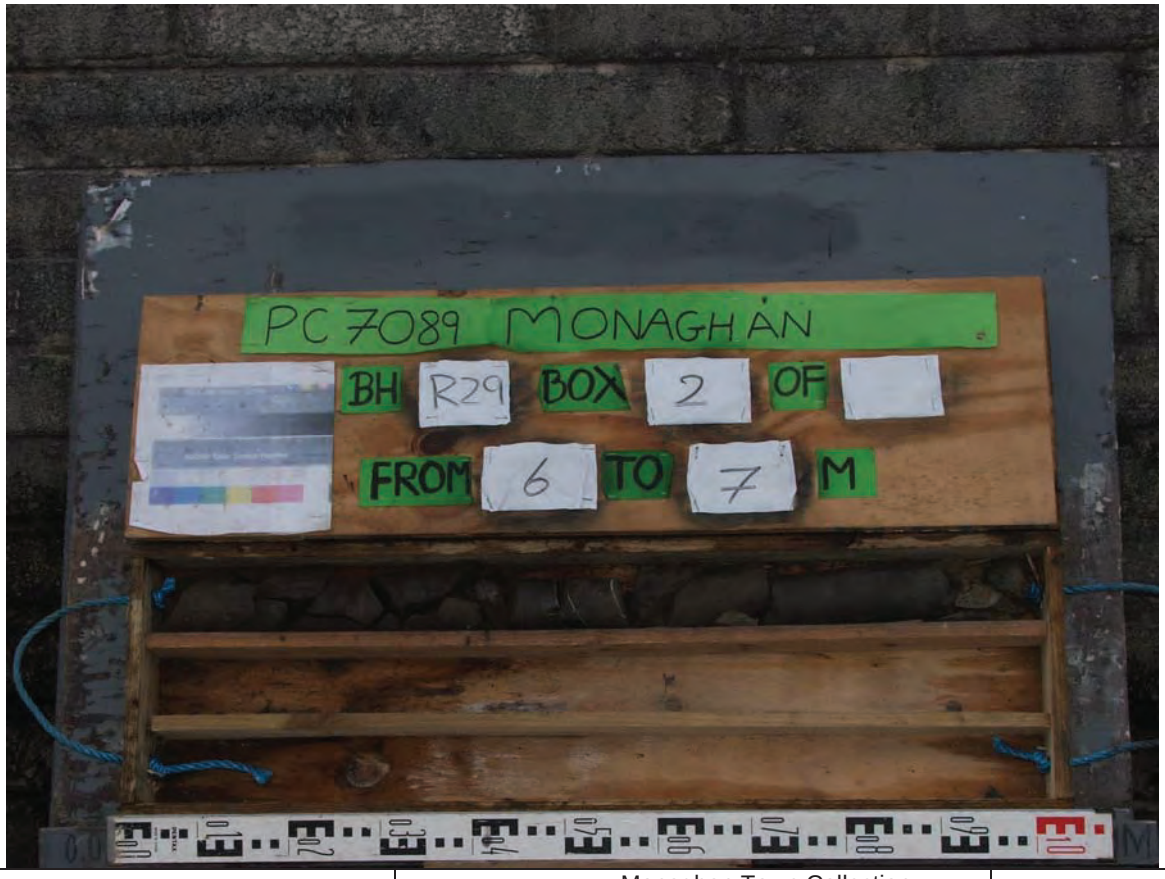
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR28**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR29**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR30**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR31**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR31**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR32**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

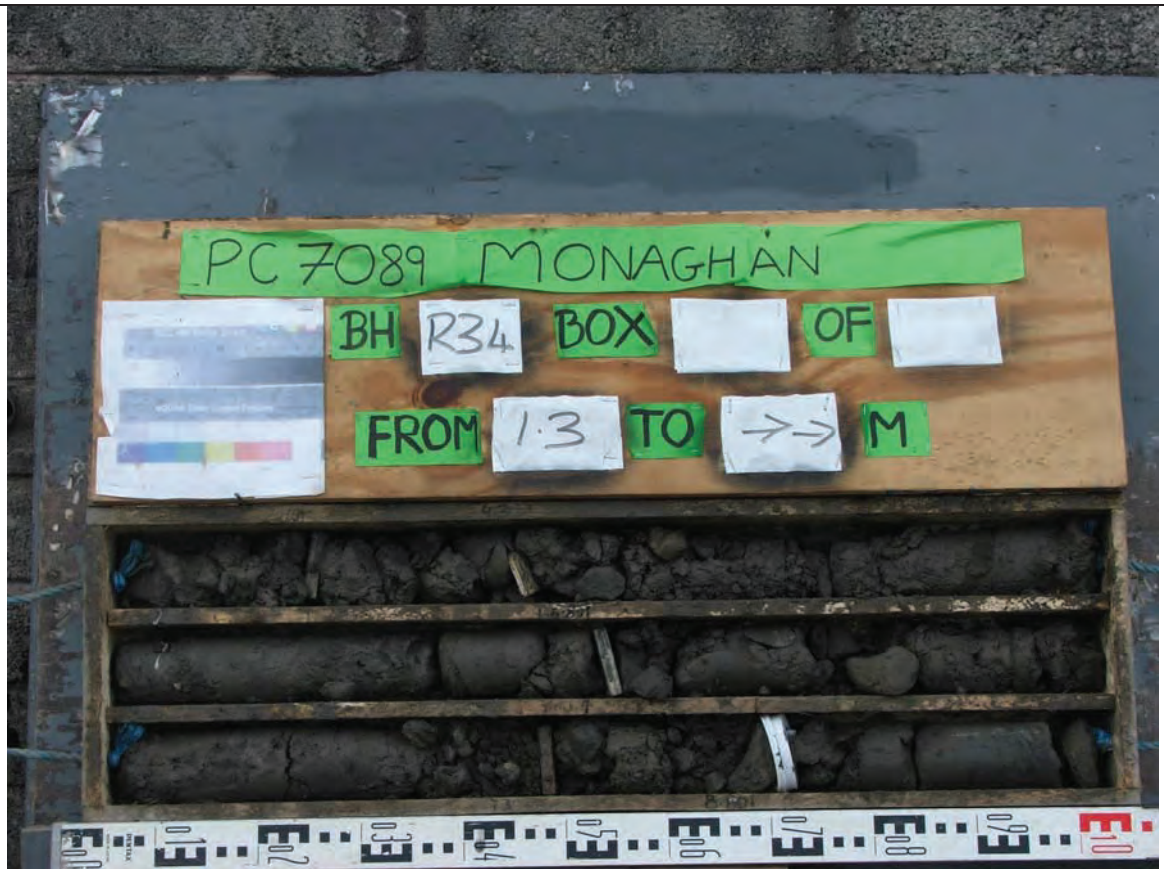
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR33**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

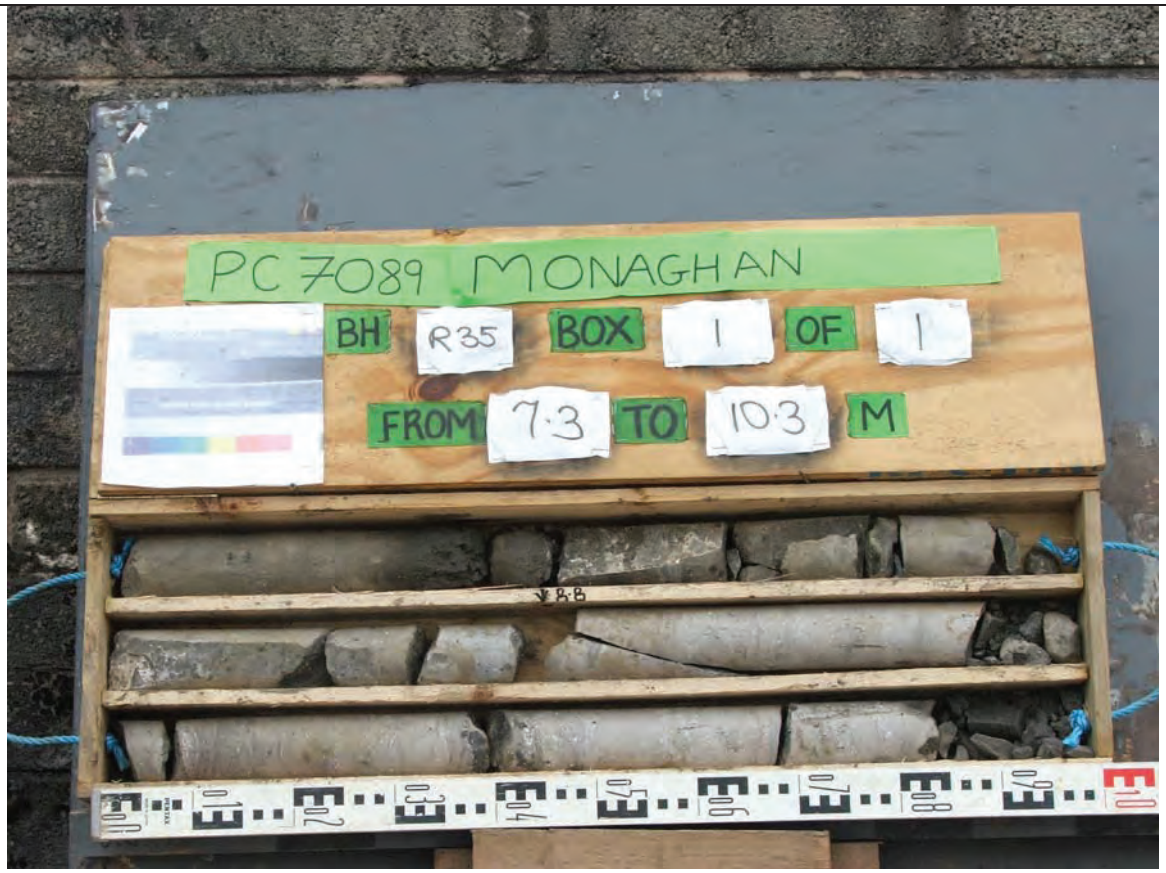
Priority Geotechnical Limited



Rotary Borehole Number:	**BHR34**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

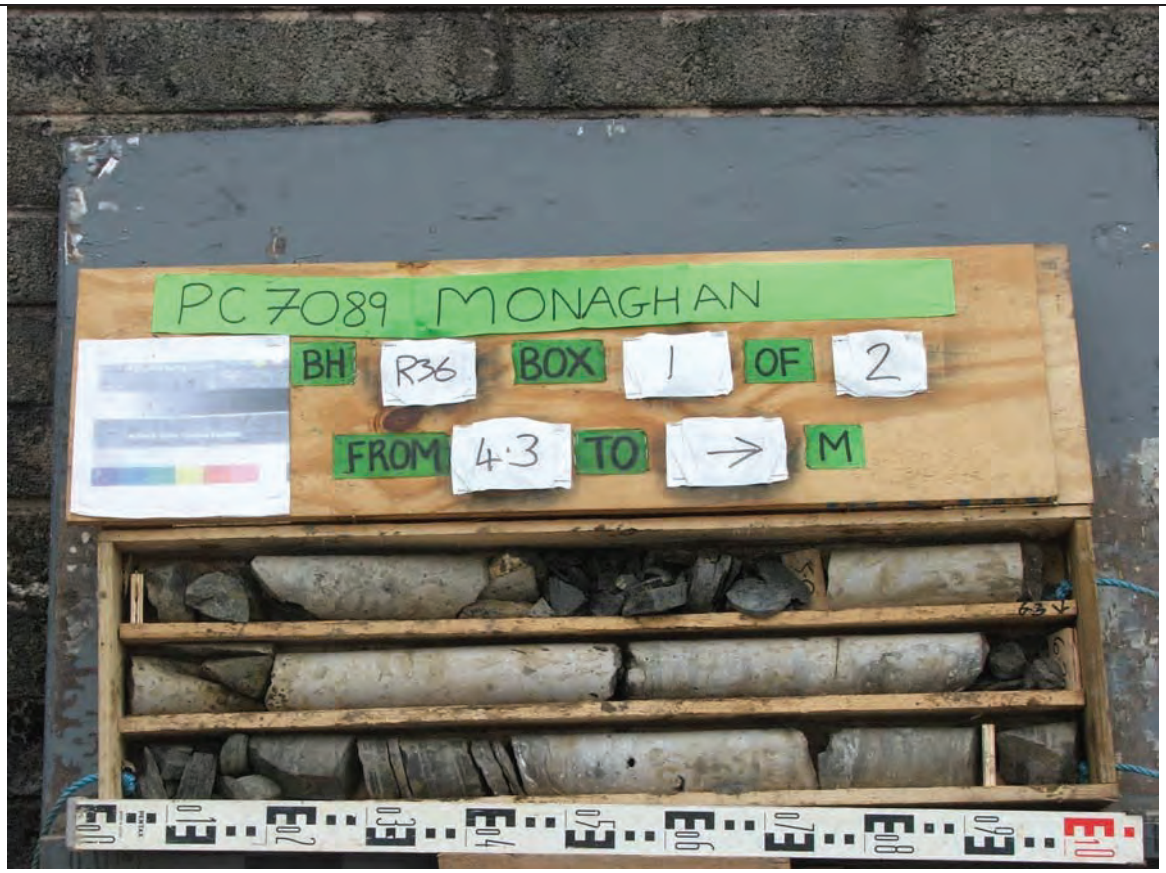
Priority Geotechnical Limited



Rotary Borehole Number:	**BHR35**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR36**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR37**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR38**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR39**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR40**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR41**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR42**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR43**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR44**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR46**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR48**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR49**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

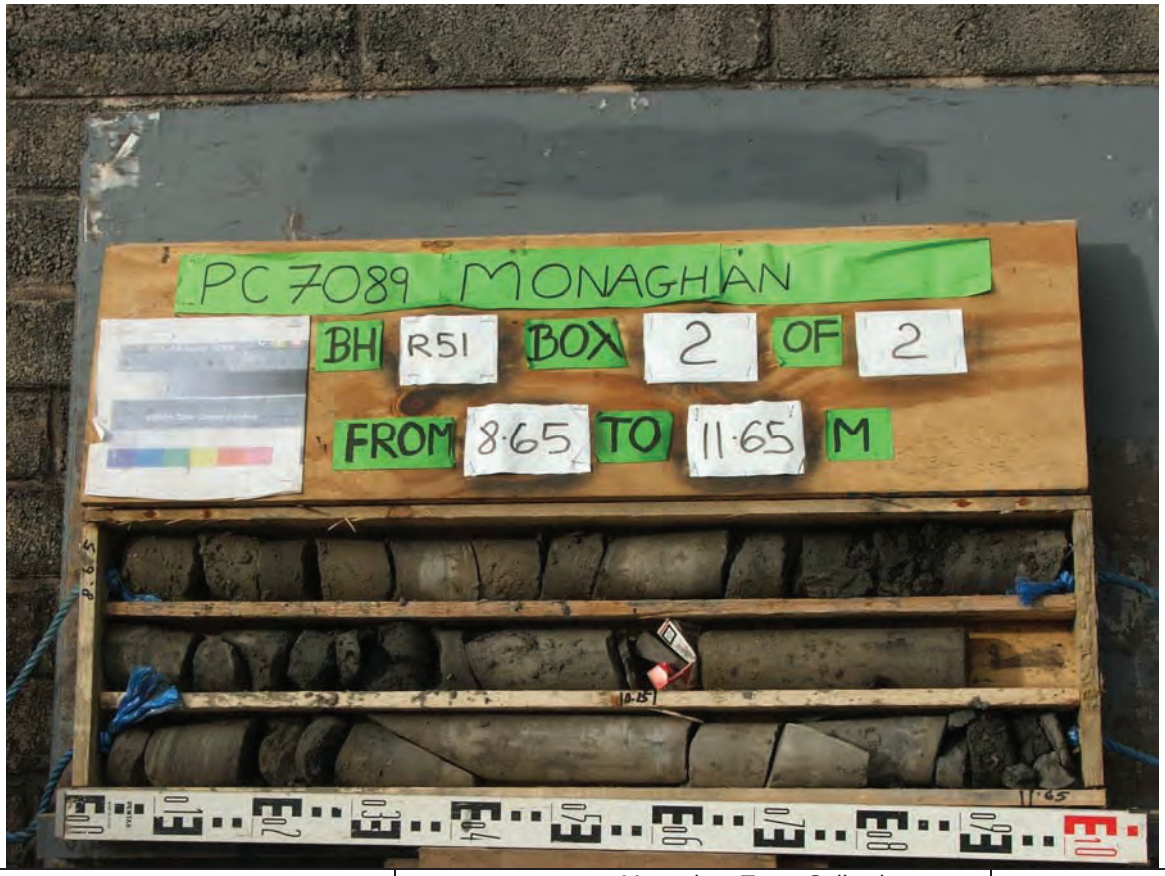
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR50**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR51**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR53**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

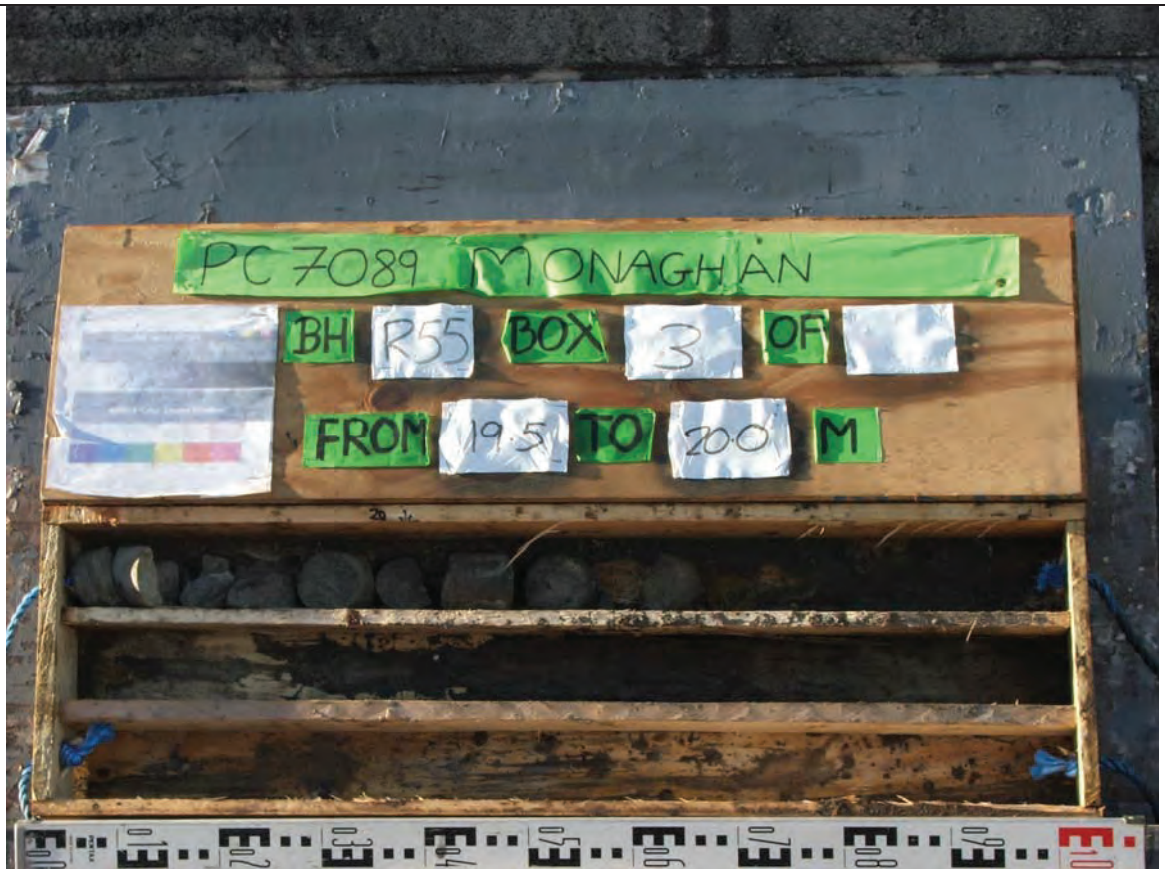
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR54**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR55**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR56**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

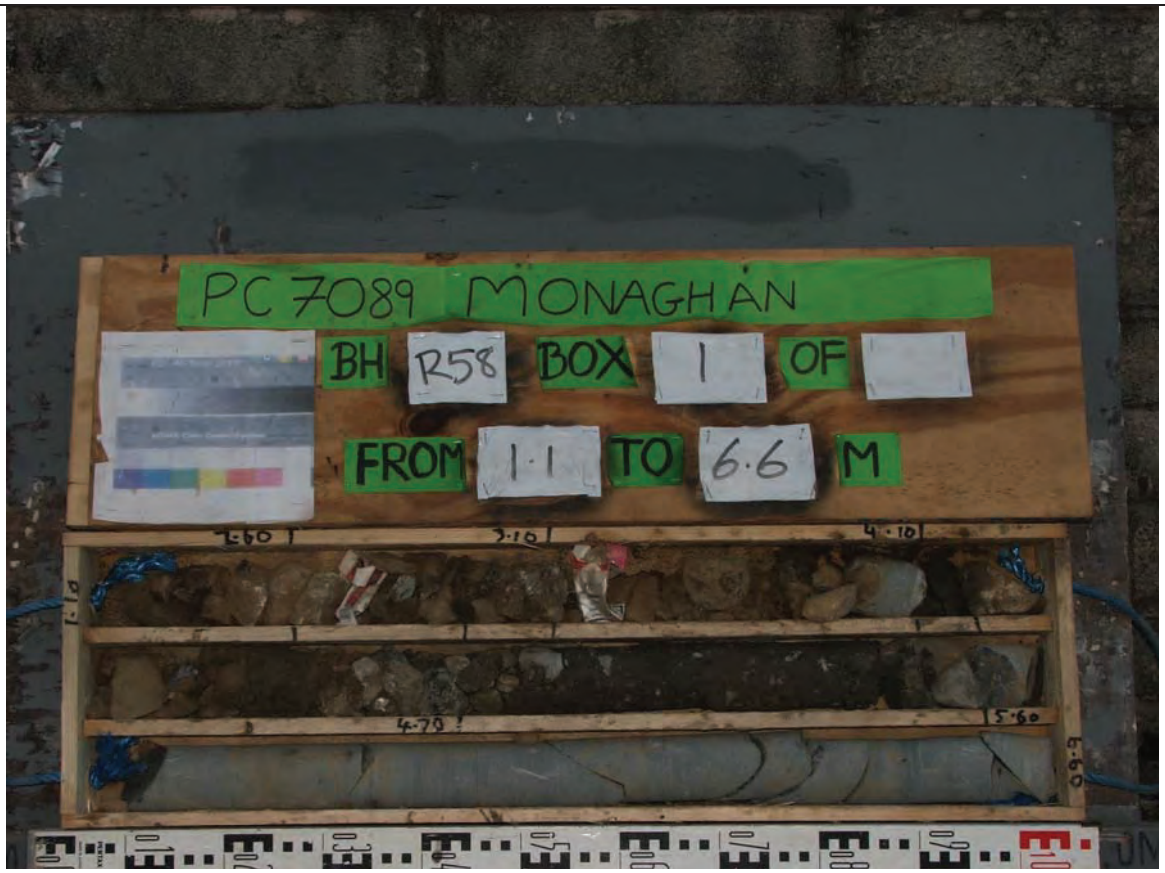
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR57**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR58**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR59**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR60**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

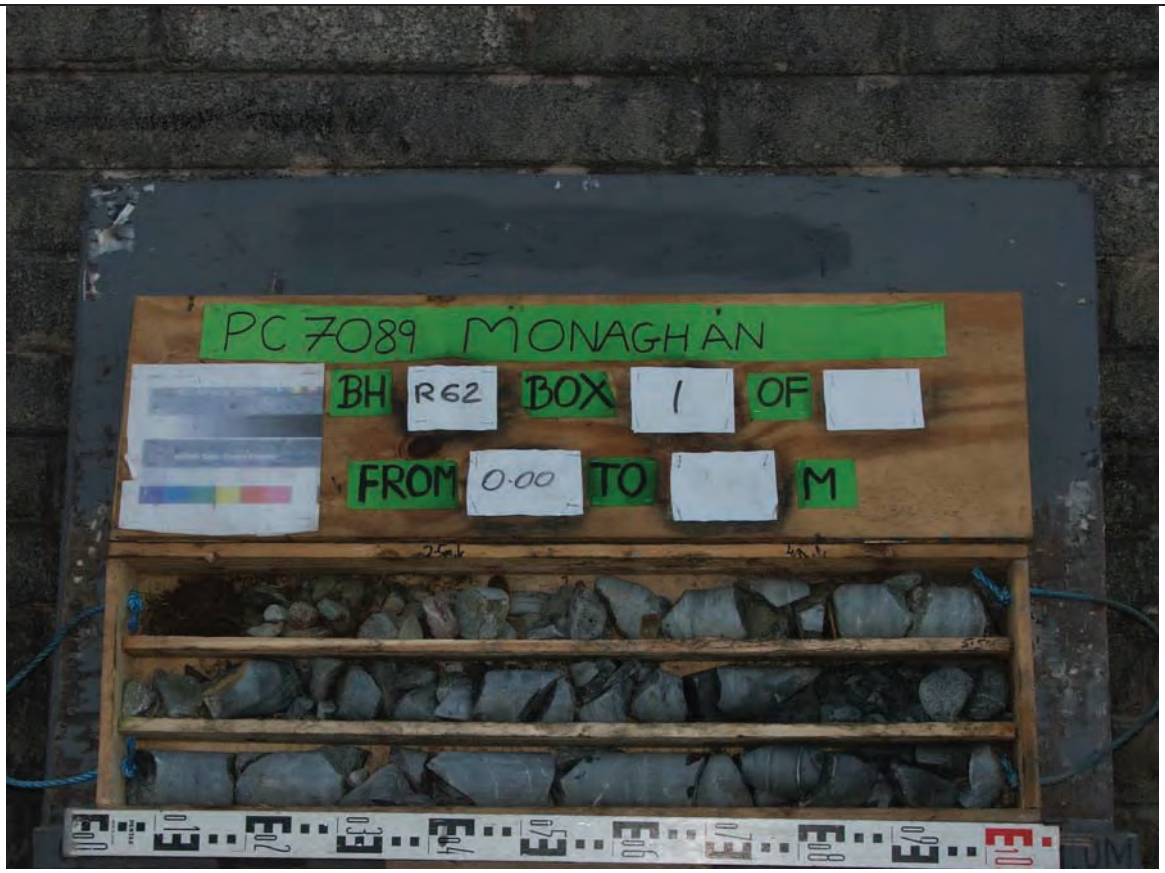
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR61**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR62**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

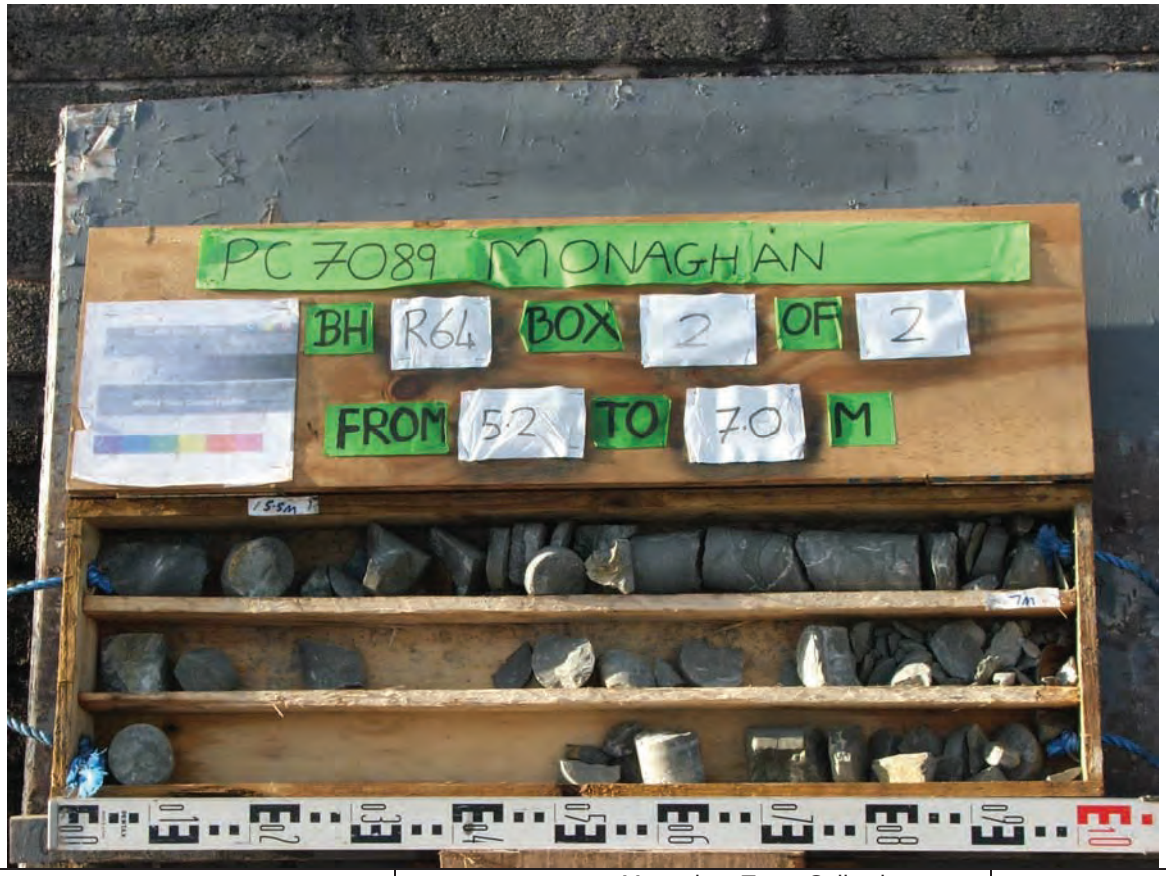
Rotary Core Photographic Record

Priority Geotechnical Limited

Rotary Borehole Number:	**BHR63**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers	

Rotary Core Photographic Record

Priority Geotechnical Limited



Rotary Borehole Number:	**BHR64**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out for	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP05**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP06**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

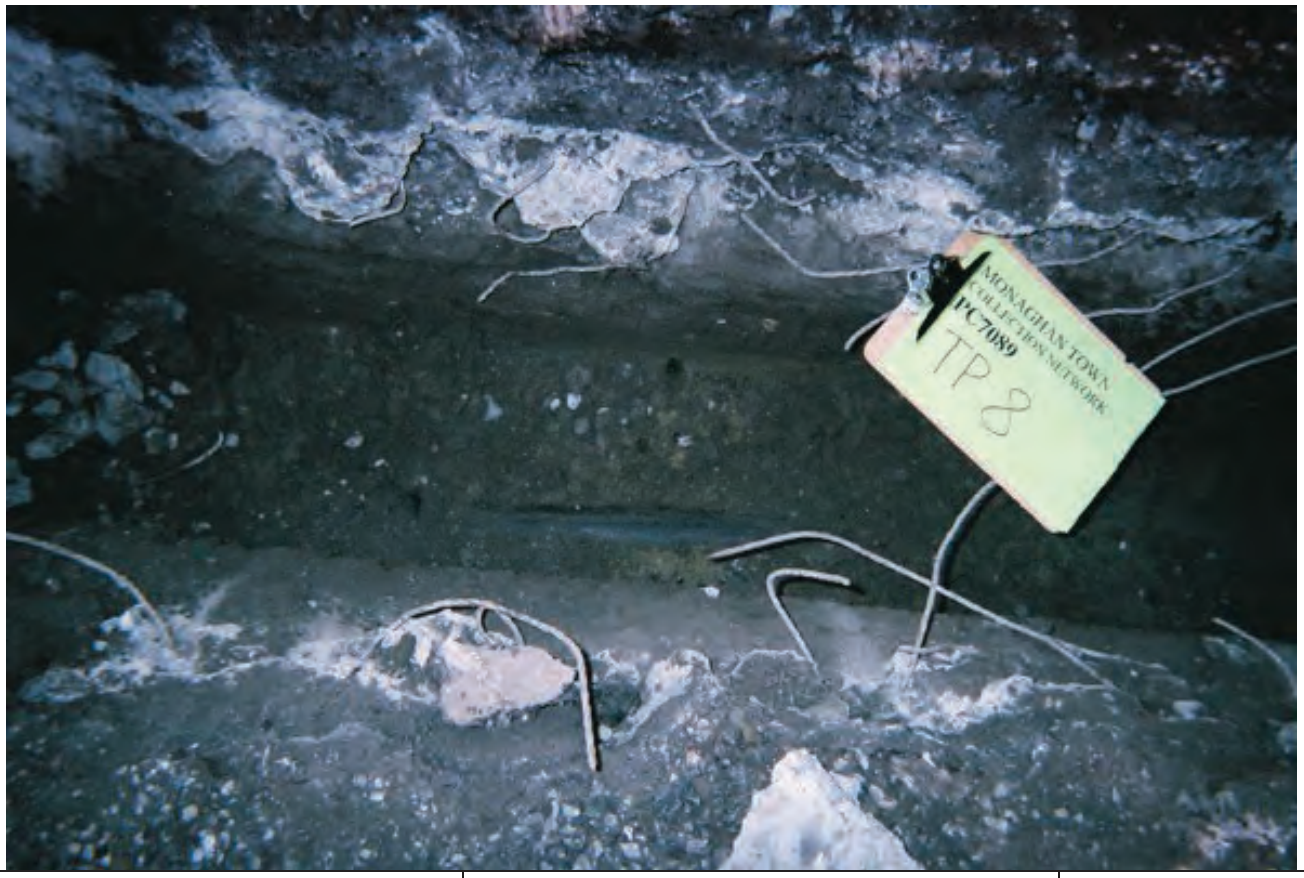
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP07**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP08**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP08**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP08A**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP15**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP15**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP16**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP17**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP18**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP18**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP19**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP19**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP20**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP20**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP21**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP22**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

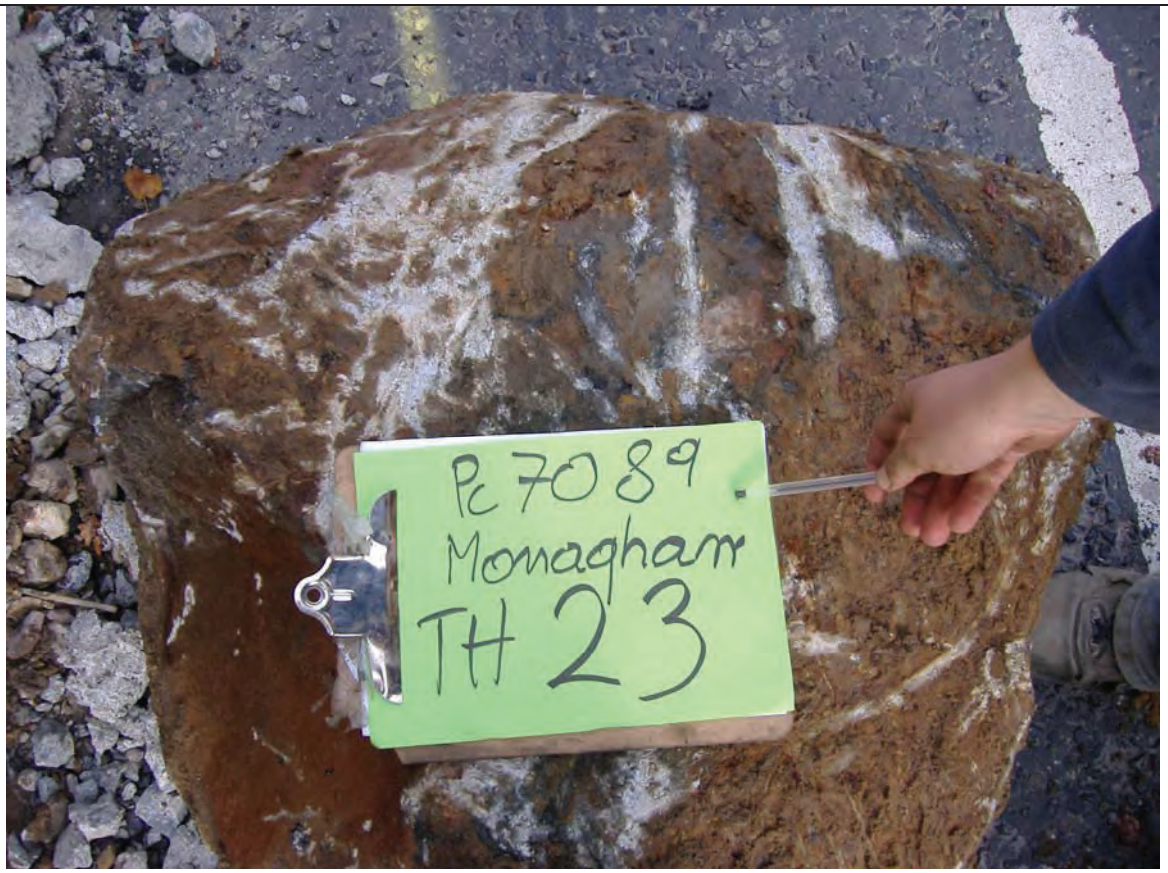
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP23**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP23**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP24**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP25**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP25**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP25**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP26**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP26**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP27**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP28**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP28**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP29**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP29A**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP29A**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP30**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP31**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP32**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP33**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP34**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP35**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP36**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP36**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP37**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP37A**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP38**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP38**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP39**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP39**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP40**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP40**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP43**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP43**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP44**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP44**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP45**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP45A**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP50A**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP55**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP55**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP57**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP57**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP58**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP59**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP59**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP60**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP60**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP65**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP65**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP66**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

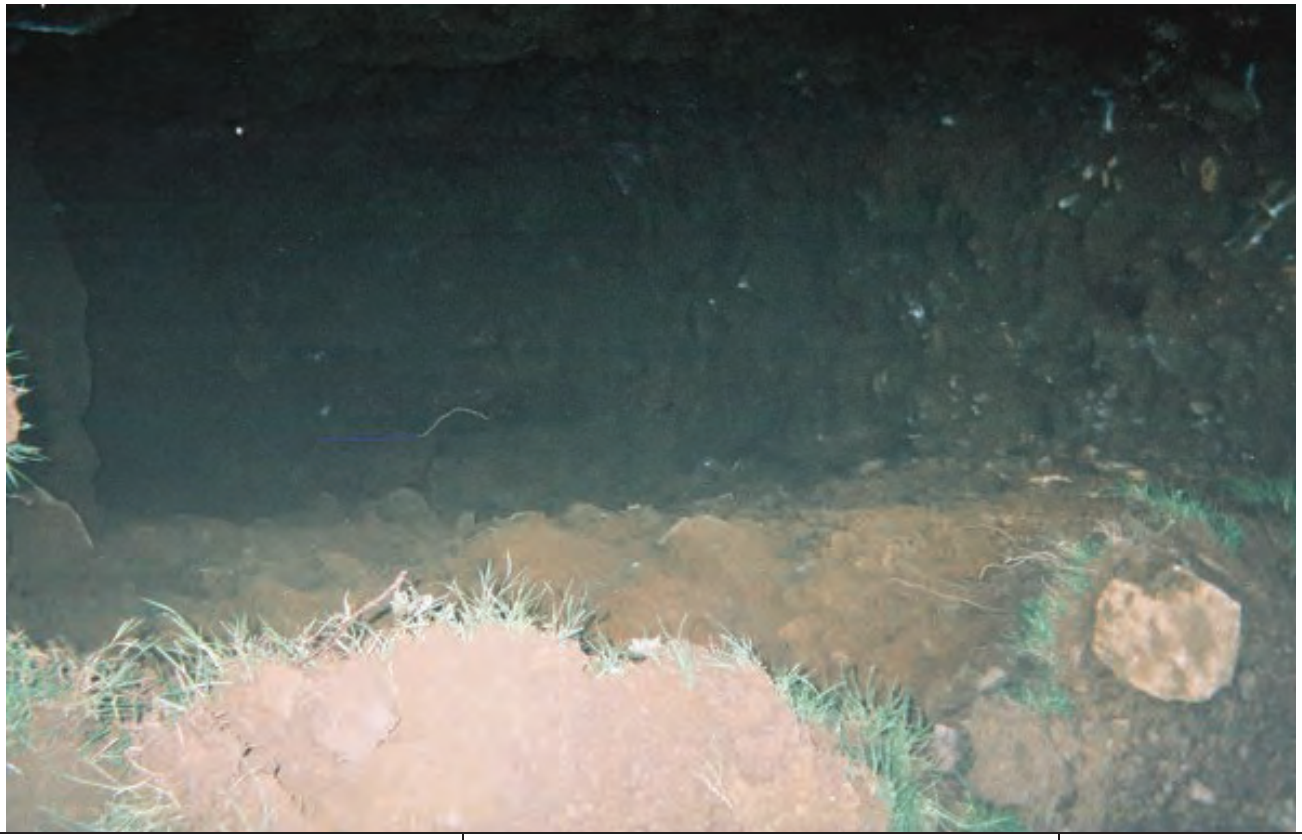
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP66**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP68**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP68**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP69**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP69**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP73**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP73**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP74**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP74**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP75**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP76**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP77**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP78**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP113**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP114**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP115**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP116**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP134**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP135**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP135**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP136**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP136**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP137**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP138**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP139**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP140**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP141**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP141**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP142**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP142**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP143**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP143**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP144**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP144**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number: **TP145**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP147**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP147**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

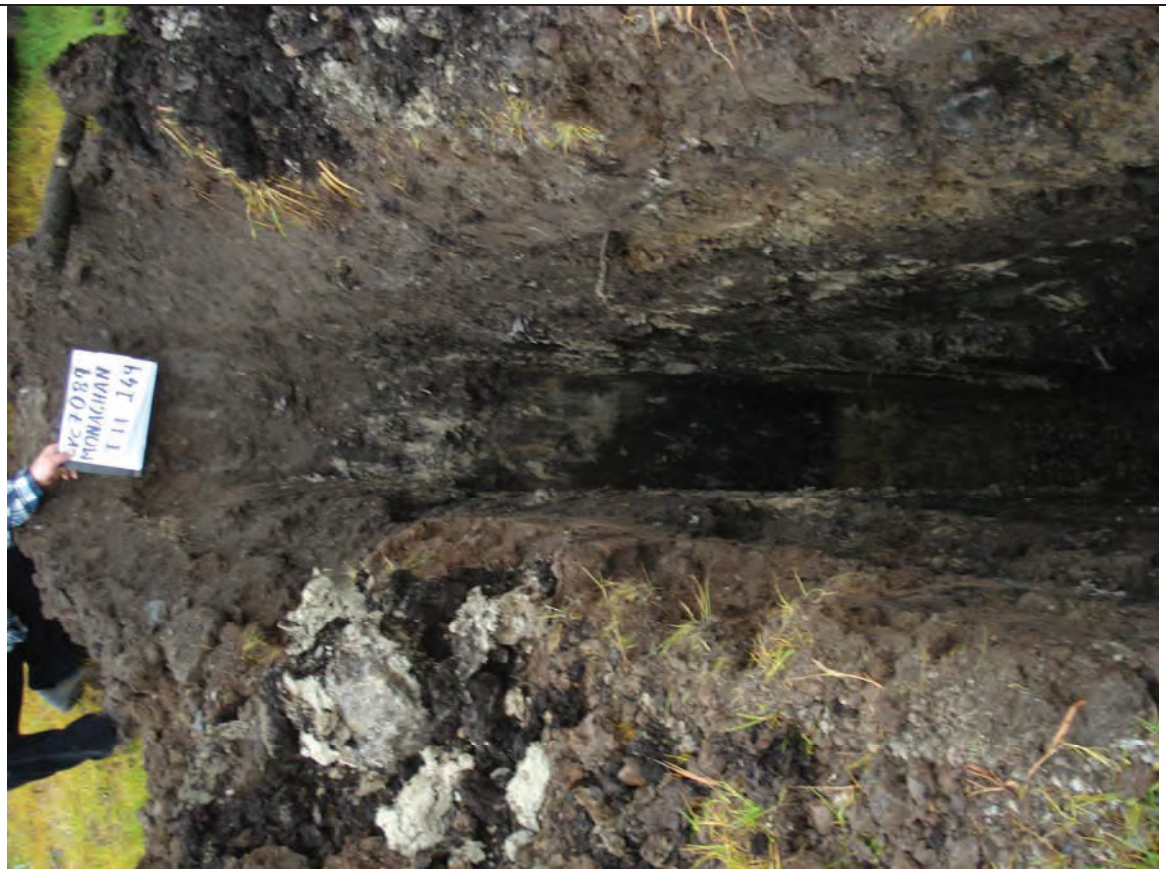
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP148**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP149**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP150**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP158**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP159**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP161**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP162**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP162**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP163**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP164**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP165**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP166**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP166**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP167**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP167**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

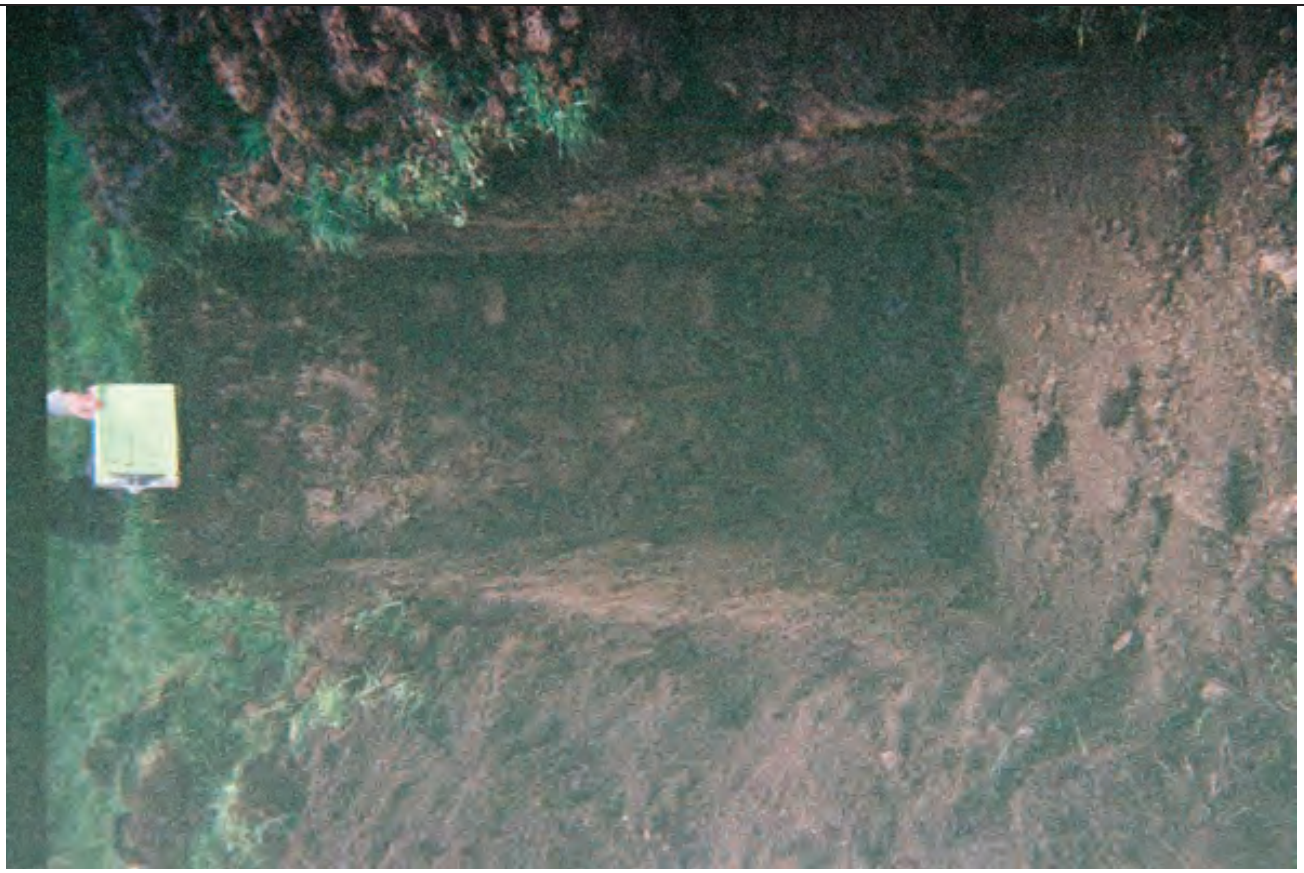
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP168**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP168**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP171**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP171**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

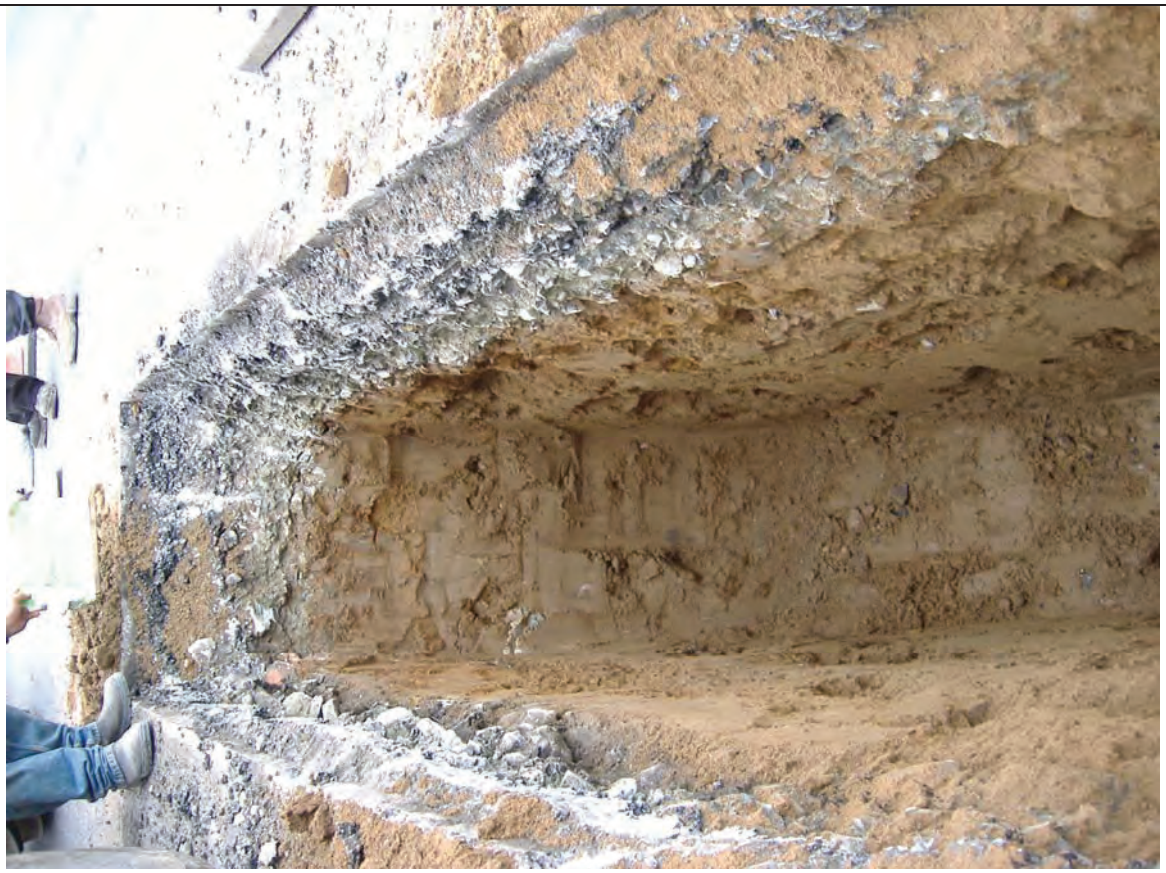
Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP172**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited



Trial Pit Number:	**TP172**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP173**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP179**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP179**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP180**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP180**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP181**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP182**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP182**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP186**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP187**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP187**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP188**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP189**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Trial Pit Photographic Record

Priority Geotechnical Limited

Trial Pit Number:	**TP184**	**Project**	Monaghan Town Collection Network	
		Project No	PC7089	
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST01A**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST01A**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST05**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

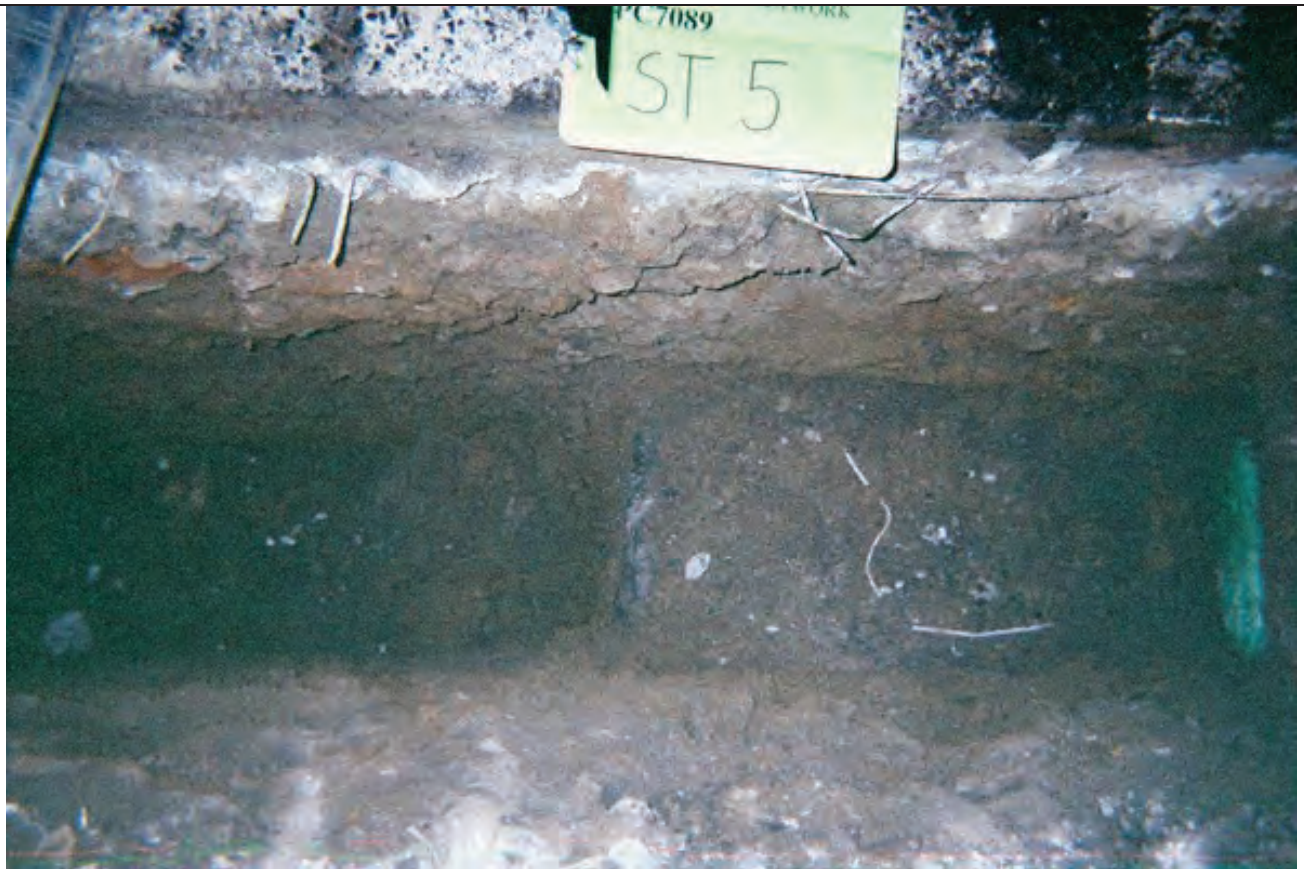
Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST05**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited



Slit Trench Number:	**ST05**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST05**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST05**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST06**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST06**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST06**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: ST07	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST08**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST08**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST08**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST09**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST09**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

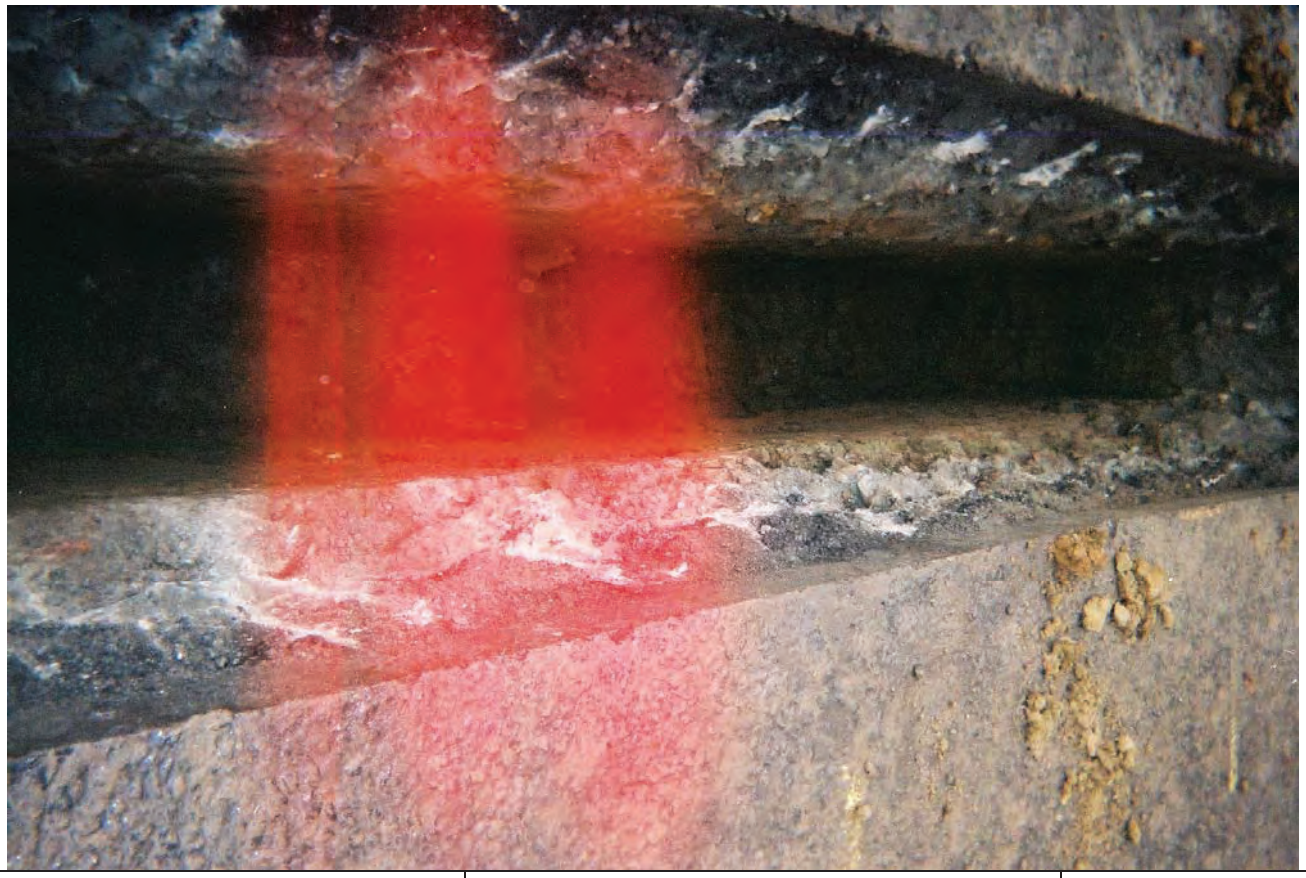
Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST09**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited



Slit Trench Number: **ST09**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST10**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST10A**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number:	**ST10A**	**Project**	Monaghan Town Collection Network
		Project No	PC7089
		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

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Slit Trench Number: **ST12**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: ST12	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST12**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST15**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST15**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

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Slit Trench Number: **ST16**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST16**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST18**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST18**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Number: **ST18**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST20**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

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Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST20**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST21**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST21**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

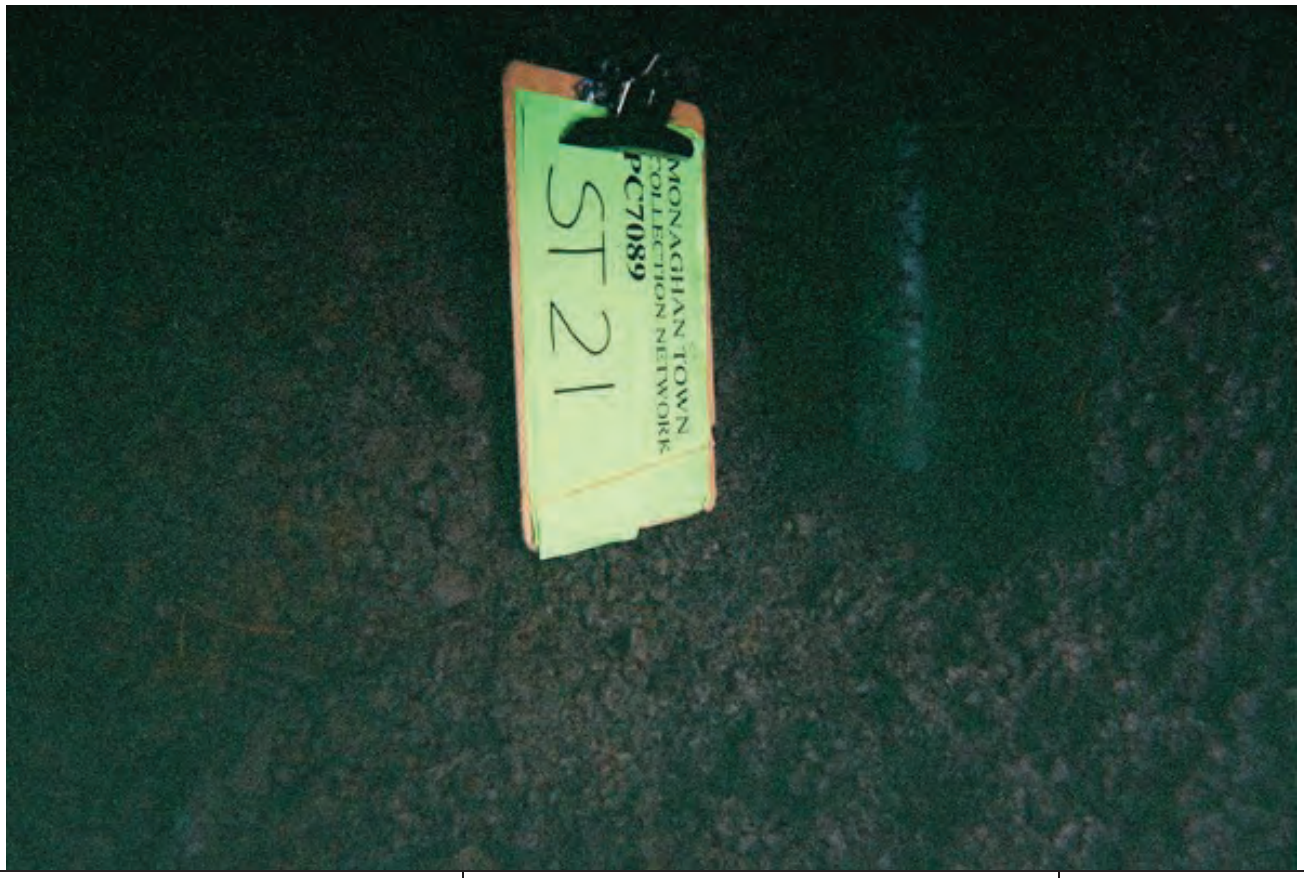
Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST21**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited



Slit Trench Number:	**ST21**	**Project** **Project No** **Carried Out**	Monaghan Town Collection Network PC7089 T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST21**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST22**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST22**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST22**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number:	**ST23**	**Project**	Monaghan Town Collection Network
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		Carried Out	T. J. O'Connor & Associates, Consulting Engineers

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST23**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST23**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

Priority Geotechnical Limited

Slit Trench Number: **ST23**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

Slit Trench Photographic Record

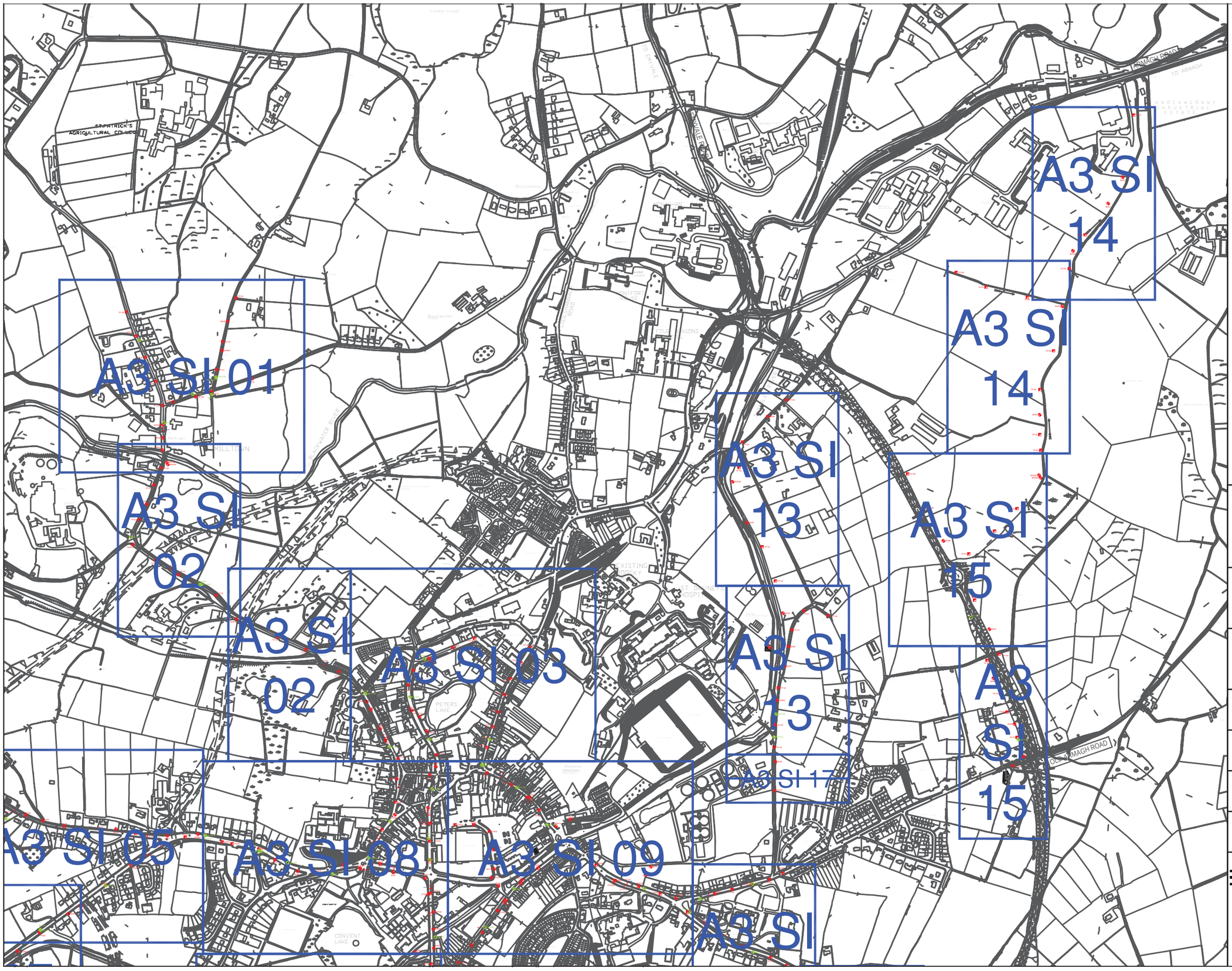
Priority Geotechnical Limited

Slit Trench Number: **ST23**	**Project** Monaghan Town Collection Network **Project No** PC7089 **Carried Out** T. J. O'Connor & Associates, Consulting Engineers	

APPENDIX D

EXPLORATION LOCATION PLANS

Key to Exploration Location Plans	Key
Exploration Location Plans	PC7089-SI-A to PC7089-SI-C PC7089-SI-01 to PC7089-SI-18



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MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089–SI–A

DRAWN BY:
Faoiltiarna Nic Chárthaigh

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20/05/2009

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REVISION:
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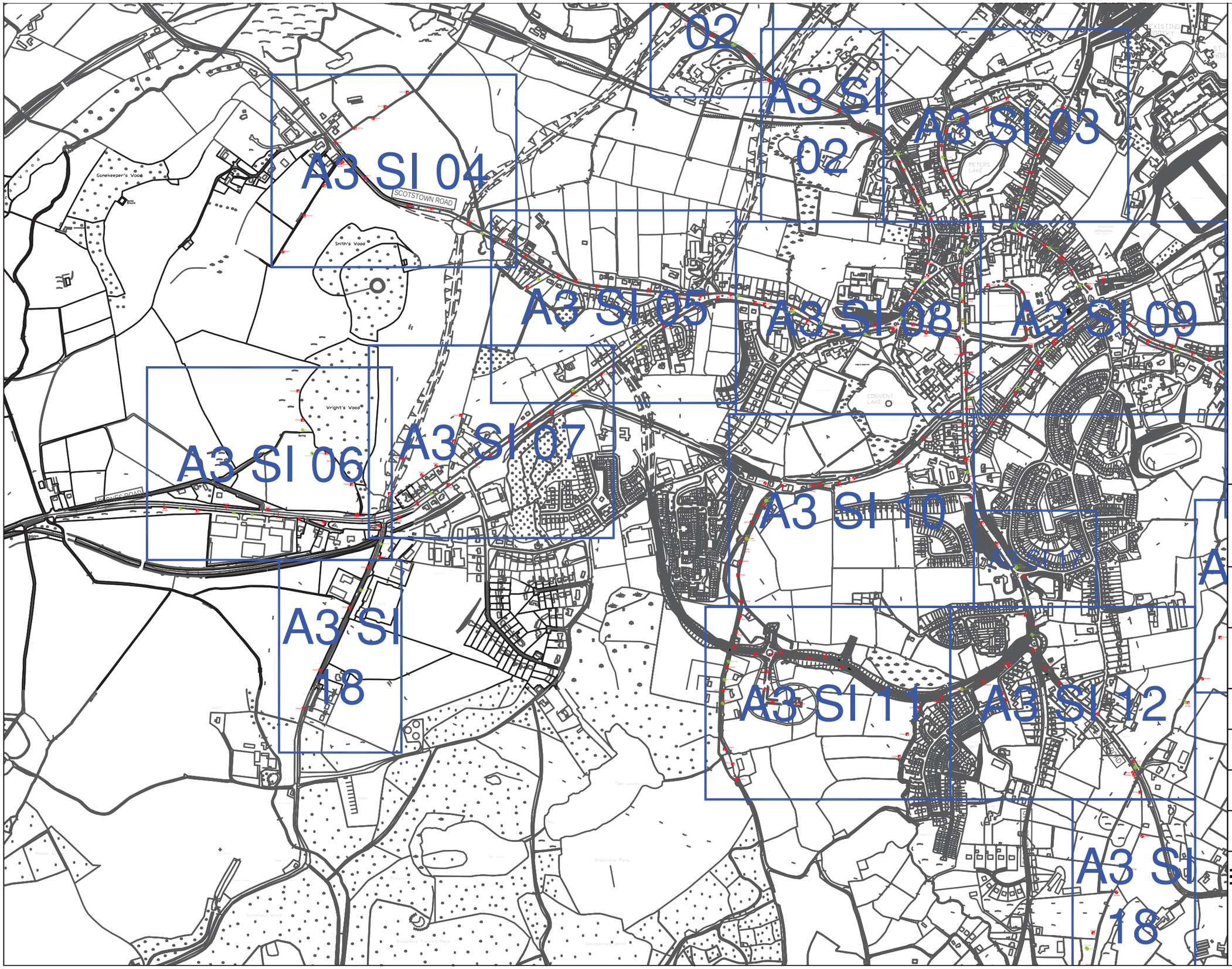

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MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089-SI-B

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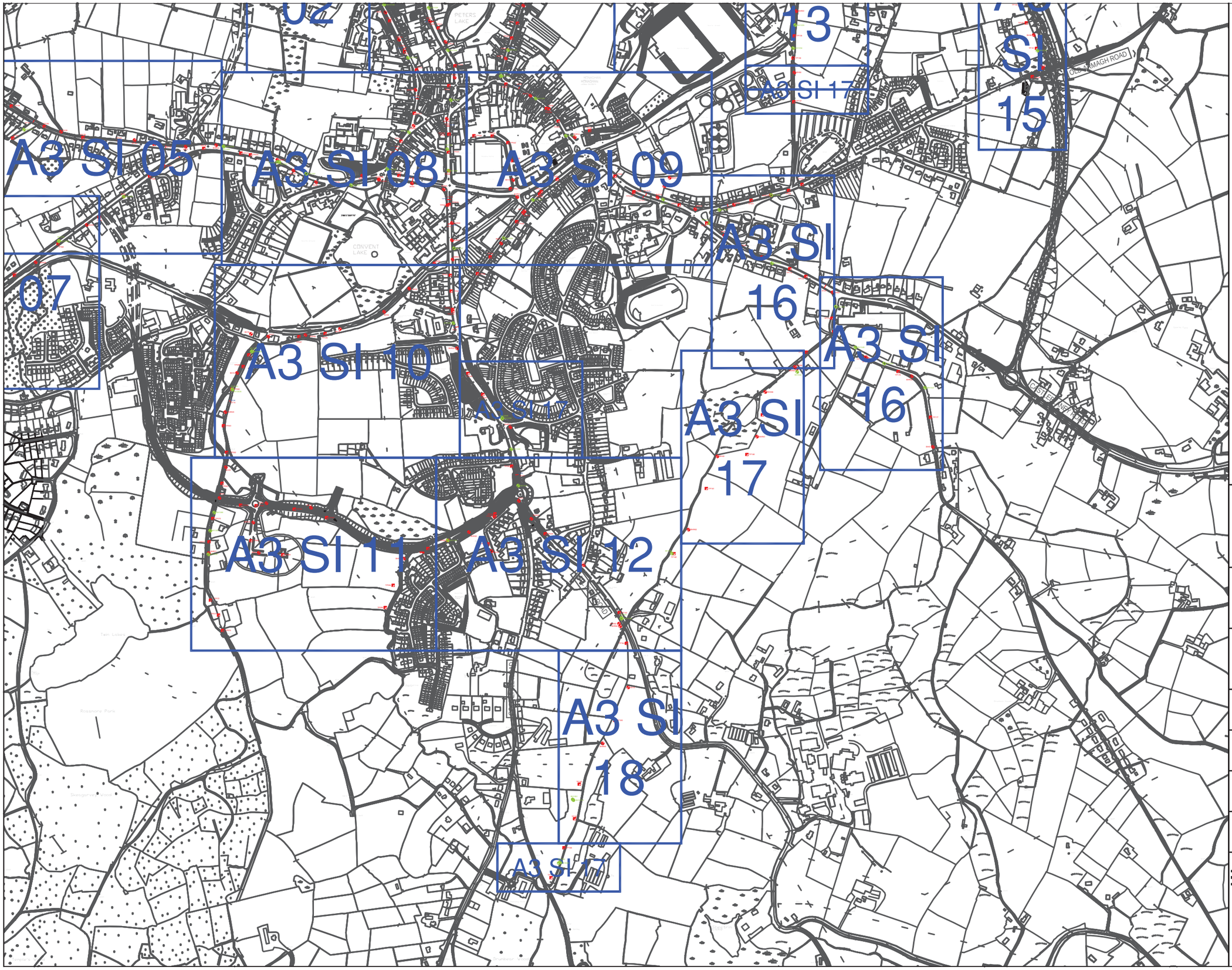

JOB NAME:

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JOB NUMBER:

PC7089

DRAWING NUMBER:

PC7089–SI–C

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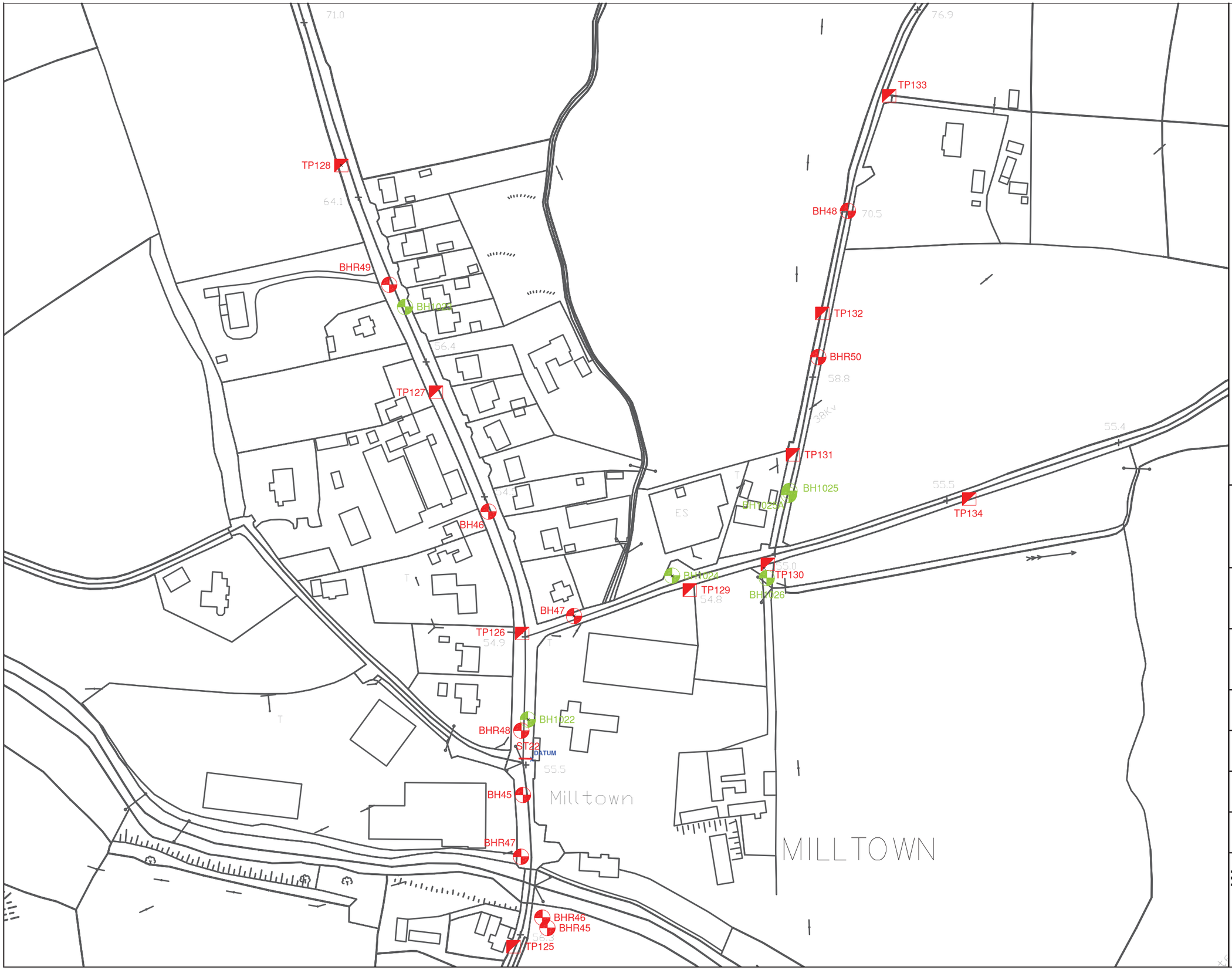

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MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC 7089

DRAWING NUMBER:
PC 7089–SI–01

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20/05/2009

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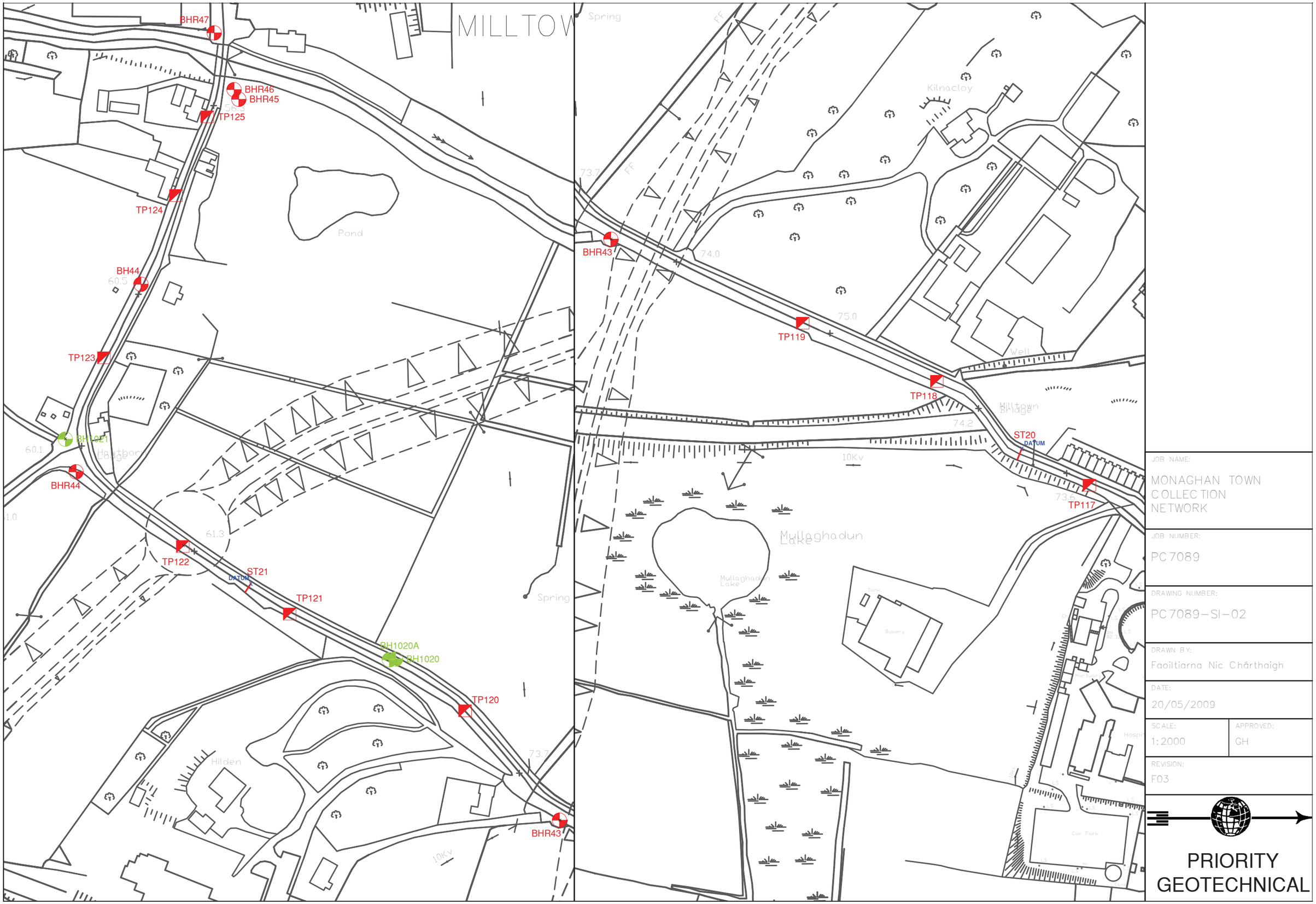

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PC 7089

DRAWING NUMBER:
PC 7089–SI–02

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REVISION:
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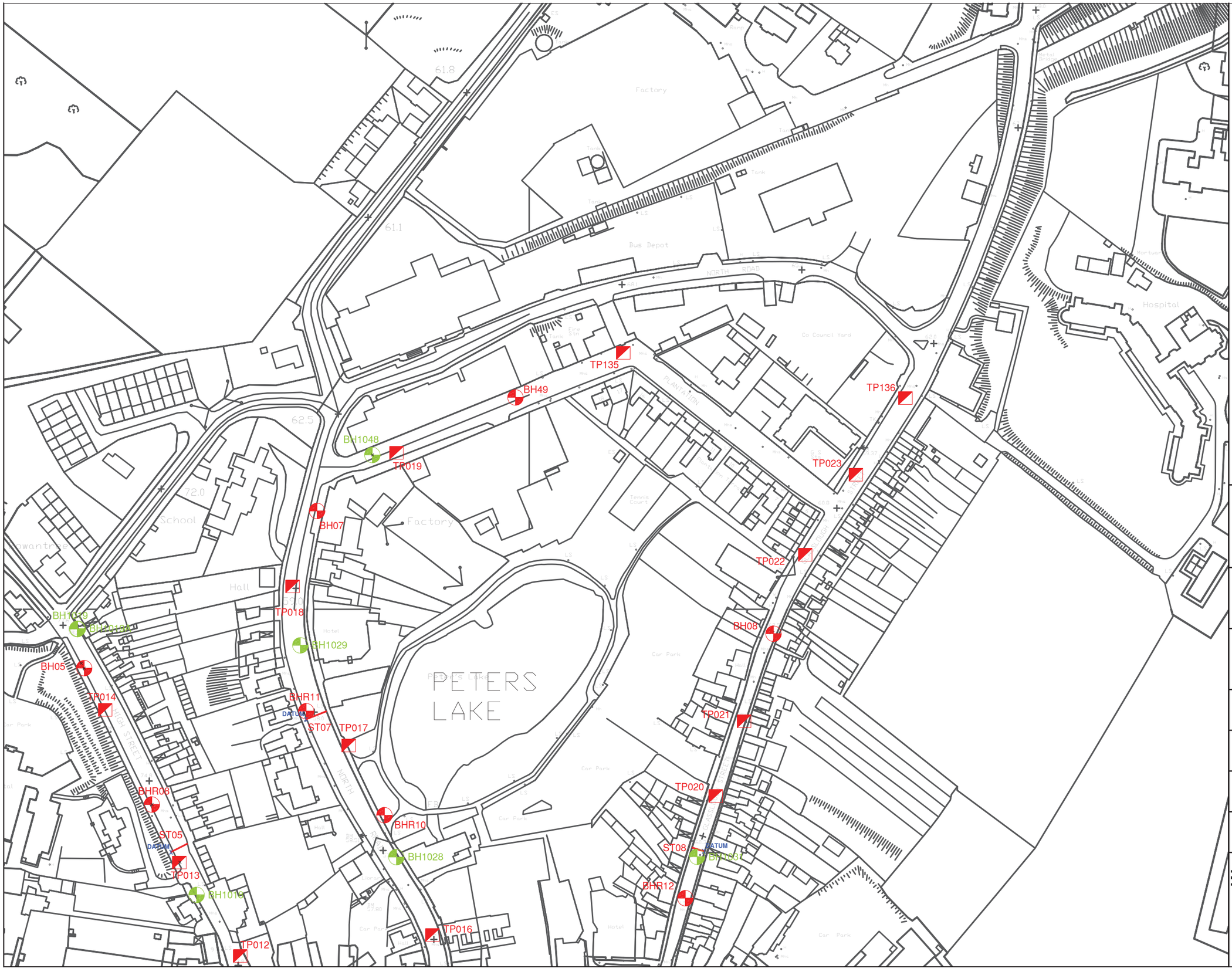

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MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089–SI–03

DRAWN BY:
Faoiltiarna Nic Chárthaigh

DATE:
20/05/2009

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REVISION:
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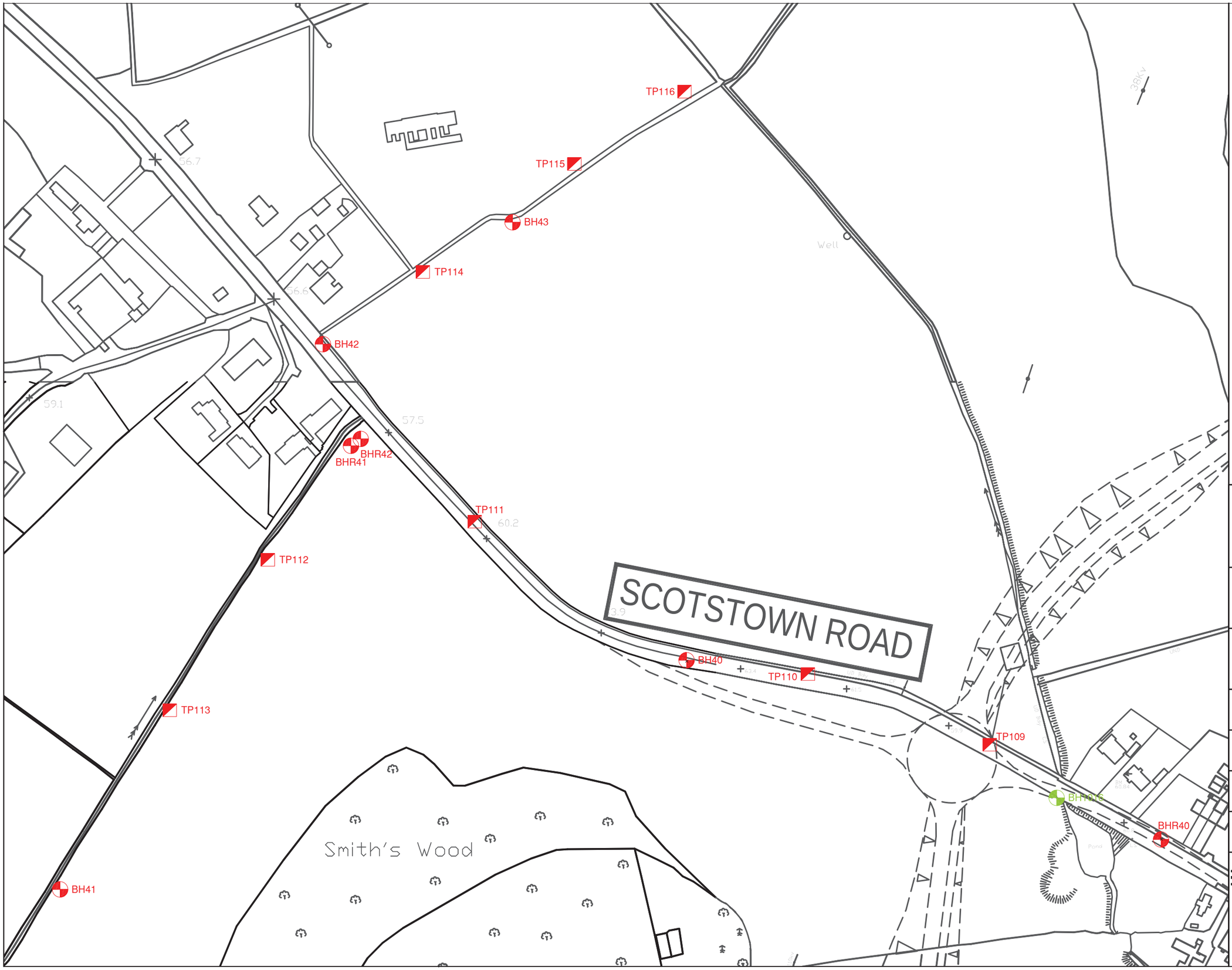
PRIORITY GEOTECHNICAL



JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089–SI–04

DRAWN BY:
Faoiltiarna Nic Chárthaigh

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REVISION:
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PRIORITY GEOTECHNICAL

BHR40
TP108
ST19
DATUM
TP106
BH1015
BH39
TP107
TP105
TP104
BH38
TP103
DATUM
ST15.1
BH27
TP078
BHR34
ST15.2
DATUM
TP079
TP080
BH28
BH1005
TP081
BH29
BH1006
BH1006A
TP082

JOB NAME:
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JOB NUMBER:
PC7089

DRAWING NUMBER:
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PRIORITY GEOTECHNICAL

Wright's Wood

TP102
TP101
BH1013
Spring
BH1012
TP100
BH37
TP099
BHR39
TP098
BH1014
TP097
BH1011
BH1010
TP096
DATUM
ST18
10Kv
Car park
Car park
TP095
BH036
BHR37
BHR38
Cortolvin Bridge
BH34
ST17
DATUM
BH1008
BH35
63.0
61.1
65.4
59.6
60.8
60.6
60.3
59.7
59.5
60.0
60.4
60.8
60.9
59.9

JOB NAME:
MONAGHAN TOWN
COLLECTION
NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089-SI-06

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PRIORITY
GEOTECHNICAL

TP085
TP086
TP083
TP084
BH29
BH1006
BH1006A
TP082
BHR35
Ulster Canal
BH30
DATUM
ST16
BH31
BH32
BH33
TP087
TP089
BH1007
BHR36
TP088
Cortolvin Bridge
BH34
ST17
DATUM
Factory
Cortolvin View

JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089–SI–07

DRAWN BY:
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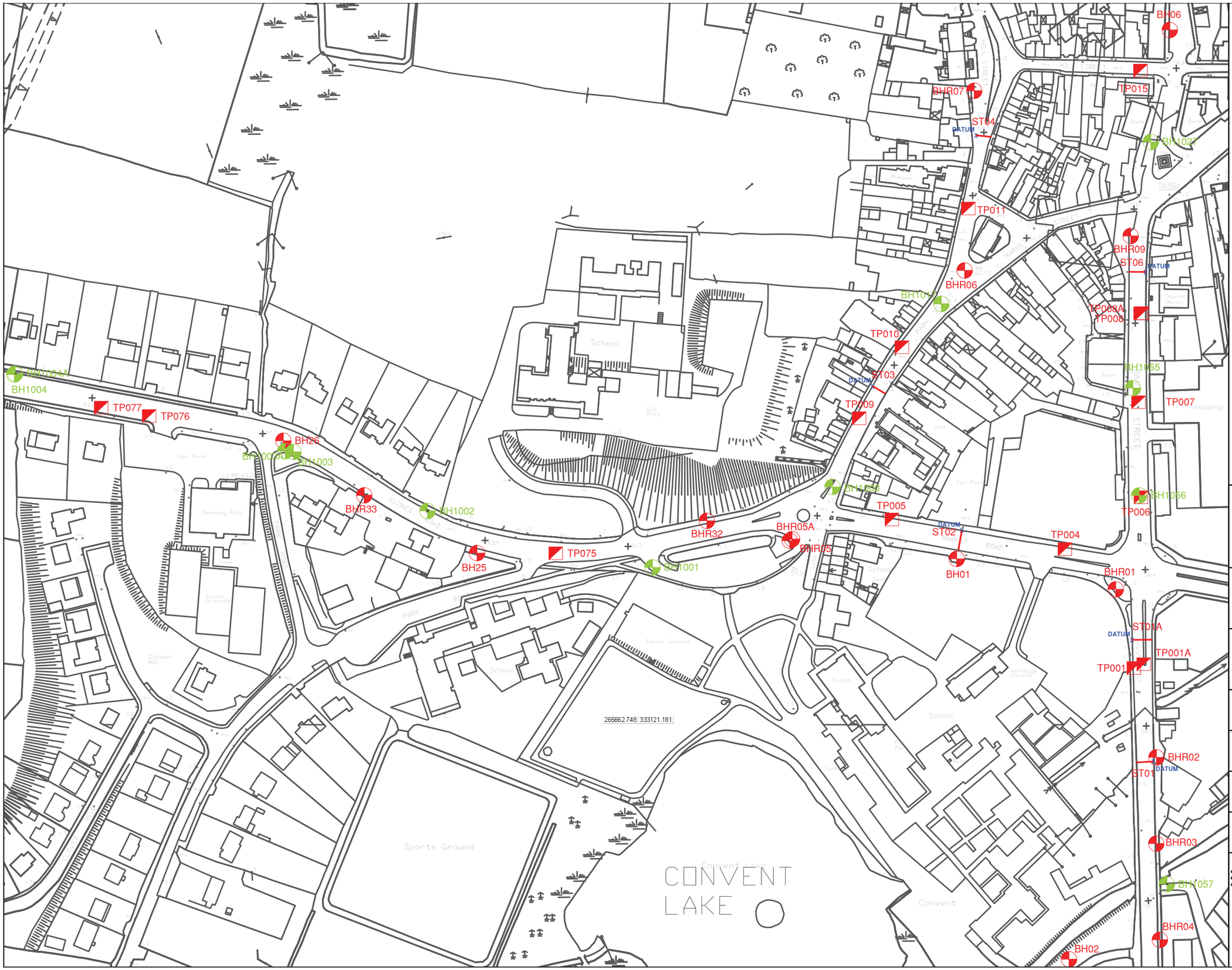

JOB NAME:

MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:

PC 7089

DRAWING NUMBER:

PC 7089–SI–08

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PRIORITY GEOTECHNICAL

MONAGHAN
MONAGHAN
(URBAN DISTRICT)

BH1030A
BH1030
TP024
ST09
DATUM
BHR13
BH1032
TP025
TP025A
TP026
TP027
BHR14
BH1033
TP044
TP043
TP042
BHR22
TP028
BHR17
BHR16
TP029
ST10.2
DATUM
TP029A
DATUM
ST10.1
BHR15
BH1035
TP030
BHR18
BH1041
TP034
TP036
BH10
TP041
TP037
TP037A
BH1053
BHR21
BH11
BH11A
TP038
BH12
BH1054
TP039

JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089-SI-09

DRAWN BY:
Faoiltiarna Nic Chárthaigh

DATE:
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SCALE:
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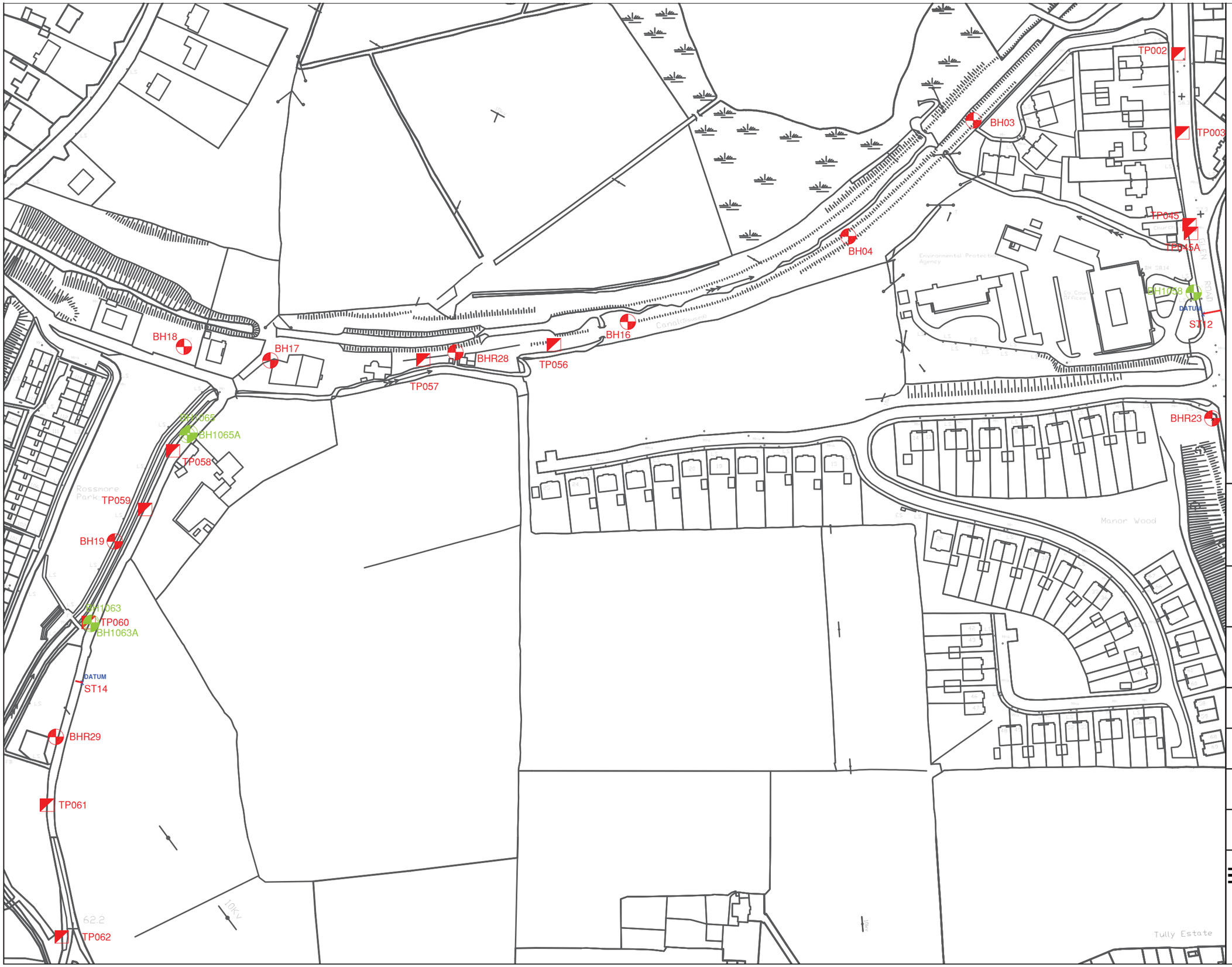

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JOB NUMBER:
PC 7089

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PC 7089–SI–10

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PRIORITY GEOTECHNICAL

BH20
TP063
BH21
BH22
TP064
TP065
TP066
BH23
TP067
BH1066
TP070
BHR30
BH1067
61.7
TP071
62.1
TP068
BHR31
BH1068
BH24
TP069
TP53
BHR27
TP054
TP055
Well
64.1
TP072
TP073
Well
TP074
67.4
Well

JOB NAME:
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NETWORK

JOB NUMBER:
PC7089

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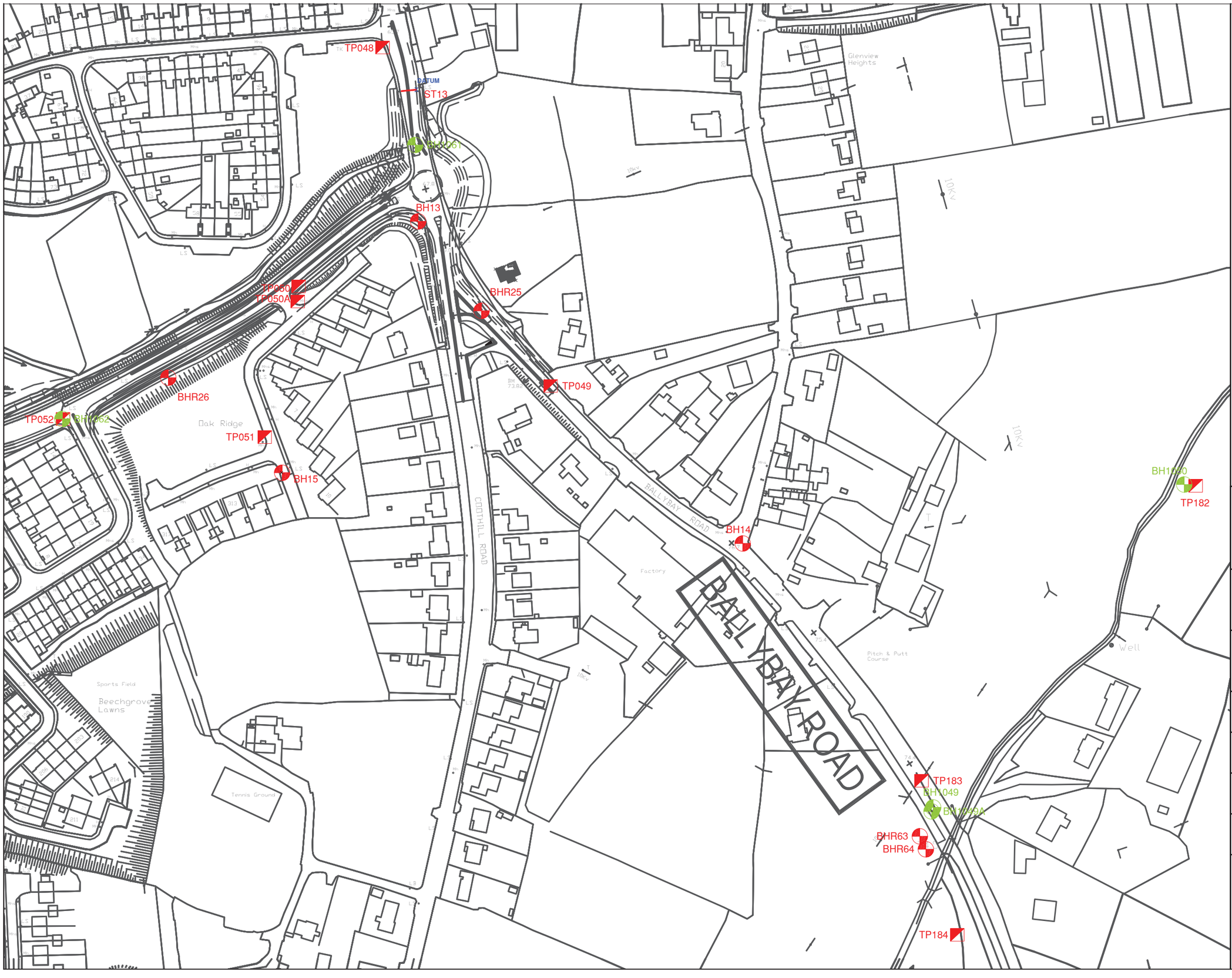

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MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

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PC7089–SI–12

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PRIORITY GEOTECHNICAL

TP146
BH55
60.5
TP145
TP144
60.0
BHR53
10Kv
65.3
BH54
66.0
TP143
64.9
TP142
Filter Beds
Sewage Treatment Plant
Tks
BHR52
55.0
BH53
TP147
TP148
Well
TP141
BH52
BH51
TP140
BHR51
BH1035
TP139
BH1034
TP138
BH50
Annahagh Close

JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

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F03

PRIORITY GEOTECHNICAL

TP168
TP167
TP166
TP169
BH60
TP165
TP164
BH59
TP163
TP162
Factory
T
TP171
Factory
Factory
10KV
BH62
38KV
BH61
TP170
BHR57
TP169

JOB NAME:
MONAGHAN TOWN
COLLECTION
NETWORK

JOB NUMBER:
PC7089

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Faoiltiarna Nic Chárthaigh

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REVISION:
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PRIORITY
GEOTECHNICAL

TP159
TP158
BH58
TP157
TP156
BH1041
BH57
BHR56
BHR55
TP161
TP160
62.9
65.6
TP155
TP154
BHR54
TP153
TP152
BH56
TP151
BH1039
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TP149

JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089-SI-15

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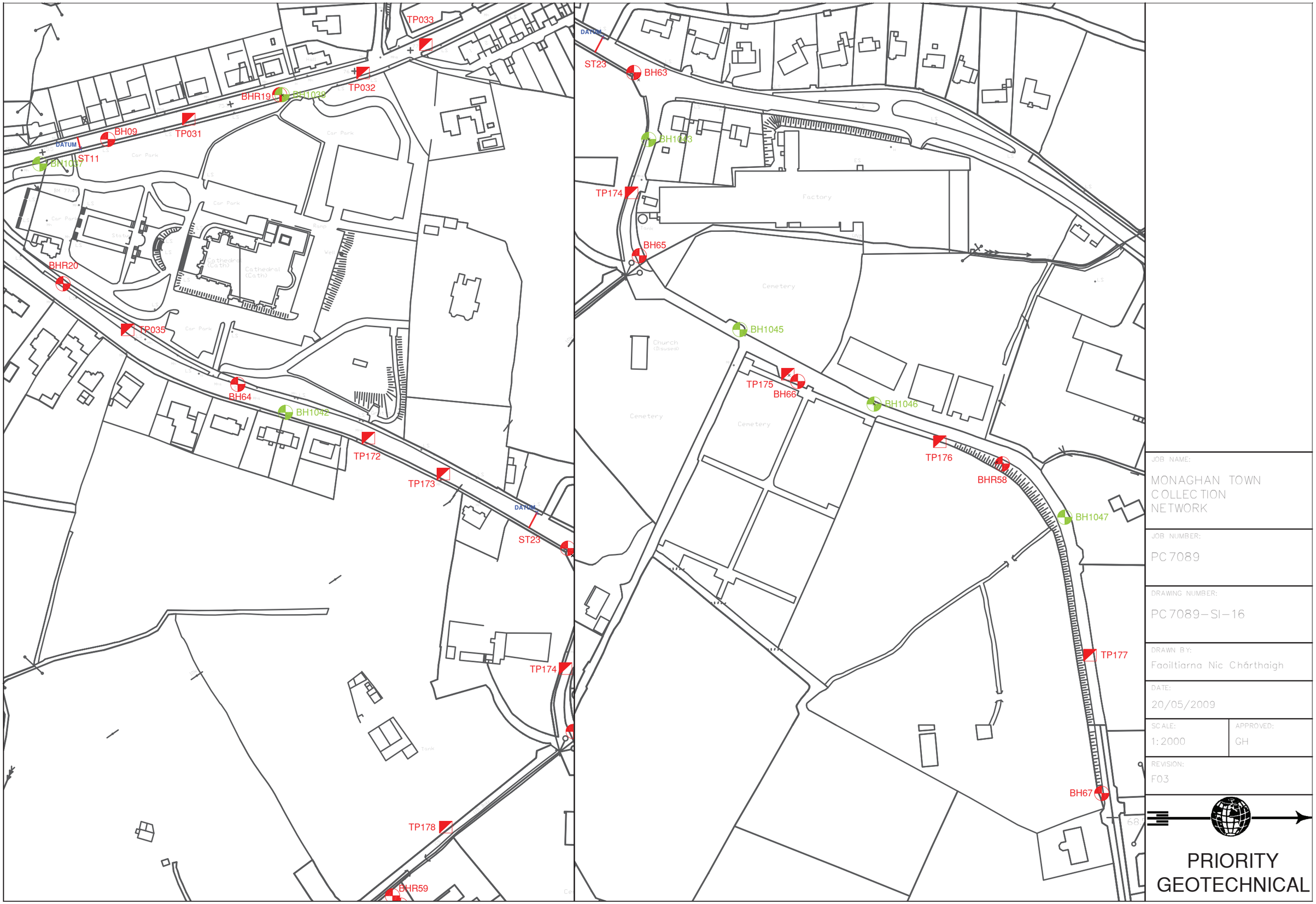

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MONAGHAN TOWN COLLECTION NETWORK

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PC7089

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PC7089–SI–16

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Faoiltiarna Nic Chárthaigh

DATE:
20/05/2009

SCALE:
1:2000

APPROVED:
GH

REVISION:
F03

PRIORITY GEOTECHNICAL

TP178
BHR59
BHR60
BH1044
TP046
TP047
BH068
Aghananimy Lough
TP179
BHR61
BH69
TP180
TP181
BHR62
GLEN ROAD
BH1060A
BH1060
BHR24
BH1060
BH50
TP137
Annahagh Close
Well
88.3
TP188
BH1052
BH1052A
TP189
Pond
Tk
Tk
85.4

JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC7089

DRAWING NUMBER:
PC7089-SI-17

DRAWN BY:
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REVISION:
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JOB NAME:
MONAGHAN TOWN COLLECTION NETWORK

JOB NUMBER:
PC 7089

DRAWING NUMBER:
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Faoiltiarna Nic Chárthaigh

DATE:
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1: 2000

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Malone O'Regan Environmental Services Ltd

Monaghan Hydrogeological Assessment Report – Impacts of Temporary Construction Works on Groundwater

Job No. 41512745
Final Report RT-NN-1257/02

January 2007

MWH

Monaghan Hydrogeological Assessment

Draft Report

Main Contributors	Aspect/Section	Notes
Kathleen Peter	Report	
Giles Farrant	Report	
Michelle Clark	Report Section 4	

Project Code: 41512745		Document No: RT-NN-1257		Controlled Copy No:	
Revision No	**Date**	**Description/Amendment**	**Checked**	**Reviewed**	**Authorised for Issue**
03	18 Dec 06	Final Report	Giles Farrant	Giles Farrant	Robin Merlane
04	10 Jan 07	Final Report	Giles Farrant	Giles Farrant	Robin Merlane

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1. INTRODUCTION

It is proposed to construct a mixed-use residential and retail development in Monaghan town centre (IGR 267326 333593). The proposed development accommodates the requirement for car parking in a three-layer basement. The basement has an approximate area of 4850 m^2 and a depth of between 9 and 12 m below ground level. The development sits adjacent to the River Shambles, which runs south-west to north-east through the centre of the town. The River Shambles flows in a heavily modified channel approximately 20 m from the proposed development. The site is currently occupied by a surface level public car park.

MWH UK Ltd have been asked to carry out modelling on the groundwater conditions in the vicinity of the site in order to make a prediction of the likely impacts that the proposed basement may have on groundwater during the construction of the basement, in order to facilitate the planning of the construction works. This report therefore considers the following items:

- Will dewatering pose difficulties during construction of the basement?
- Will the pumping rates required to dewater excavations during the construction affect local groundwater levels?
- Will the River Shambles be adversely affected by the abstraction from the river during the construction works?

The approach is to determine the hydrogeological properties of the strata beneath the site and surrounding area and collect information on waterlevels. Once these properties and waterlevels are known the MODFLOW computer code model can be calibrated to give a representation of baseline groundwater conditions. Once this baseline has been established then the effect on groundwater flow during construction can be determined.

2. BASELINE CONDITIONS

The site is underlain by karstic limestone of Carboniferous age. In the north-east of the site the limestone is close to the surface covered only by approximately 3 m of Tarmac, Made Ground and clay. Whereas to the south-west the limestone gets progressively deeper probably due to erosion by the River Shambles channel. In some locations the limestone is directly overlain by a clay that is 1 to 2 m thick followed by a gravel of 2 to 5 m thick capped with clay, silt, peat deposits, Made Ground and Tarmac up to 6 m thick. In the south of the site, near the river the gravel and limestone are separated by approximately 5 m thickness of clay with cobbles between 8 and 15 m depth. The ground investigation data would indicate that the clay deposits are laterally discontinuous layers with the gravel layer being seen in all boreholes. It is possible that the layers of clays above and below the gravel create local partially confined areas of aquifer in the valley floor.

Baseline conditions were established by monitoring groundwater and river levels for approximately 1 month between 22 September and 24 October 2006. The locations of the monitoring wells and river stage monitoring locations are shown on **Figure 1** as MW1 to MW5 and RMP. The pumping well for the constant rate test is shown as PW1. **Figure 2** shows the results of the datalogger recordings for this period in the bedrock limestone aquifer. This data demonstrates that, as expected, river levels respond very quickly to rainfall events. Although groundwater levels do not rise and fall as dramatically as river levels the response in groundwater is equally sharp and immediate. This data also indicates that the peak groundwater levels occur slightly before or during periods of storm flow of

the river and therefore it is likely that there is also a component of recharge directly from rainfall as well as the river.

Figure 3 shows the groundwater levels recorded in the monitoring wells with response zones in the limestone and gravel. This figure indicates that the groundwater levels in the limestone are sometimes higher than in the overlying gravel alluvium (e.g. MW5 during the constant rate test). This suggests that the limestone may be partially confined at this locality.

2.1 Falling Head test in Pumping Borehole

Falling head tests on the pumping borehole were carried out on 22nd October 2006. A total of four tests were carried out. The observed drawdown was then used to calculate the hydraulic conductivity of the limestone aquifer (K). K values were obtained ranging from 1.21×10^{-3}m/s to 1.42×10^{-3}m/s, with an average value of 1.32×10^{-3}m/s. K was calculated using the method of Hvorslev (1951) described in British Standard 5930 (Code of practice for Site Investigations). The difference in the values obtained from the different tests is very small indicating good data quality. However, different methods for calculating K can yield considerably different values, and this is why a constant rate pumping test was carried out. The results observed as a typical hydraulic conductivity for a karst limestone [Ref. 1].

Table 1 – Falling Head Test Results

Test Number	Hydraulic Conductivity (K) m/s
Test 1	1.21×10^{-3}
Test 2	1.29×10^{-3}
Test 3	1.36×10^{-3}
Test 4	1.42×10^{-3}

2.2 Constant Rate Pumping Test

A constant rate pumping test was carried out between 25th – 28th October 2006 at a rate of 5 l/s. During the test, water levels were monitored in the pumping well, observation wells screened in the limestone (MW3-D, MW5-D, and MW2) and the drift deposits (MW5-S and MW3-S). The stage in the River Shambles was also monitored adjacent to the site. Daily rainfall totals were also received for a monitoring station in Co. Monaghan, and are plotted alongside all the groundwater and river levels in **Figure 4** for this period. The water levels in the pumping well respond to pumping with a maximum drawdown of 10 m as shown in **Figure 5.**

The groundwater and river levels in **Figure 4** demonstrate that on the 25th October 2006 (the day of the start of the constant rate test); a large rainfall event occurred with a total of 26.7 mm of rain falling during that day. On starting the test initial drawdown was only observed in MW5-D, MW3-D and MW5-S, with a maximum drawdown from rest water levels of 0.2 m in MW5-D occurring after 1 hour. Following this, the recharge caused by the heavy rainfall overwhelms the declining water levels and the water levels in all wells rise by approximately 0.5m whilst the river stage rises by 0.7 m. The rise in the river stage is not as sharp as the increase in groundwater levels and occurs over a longer period. Therefore it is likely that rainfall events transmit very rapidly to the aquifer, the river is in good connection with the aquifer, and at this point it is receiving flow from the limestone. Part of the river flow will be from surface water runoff, although it appears that baseflow is a significant component of the river flow at this location. The proportion of surface water runoff is likely to vary substantially over the course of a year, and will depend on the antecedent conditions in the entire catchment.

As the rainfall event and subsequent recharge dominates the response in the limestone to pumping, the constant rate test is difficult to analyse using conventional analytical methods of pump test analysis. However an estimate of permeability has been completed using the aquifer recovery data. It is assumed that the after 3 days of the constant rate test the drawdown has reached a steady state as a result of pumping. The recovery in the aquifer is rapid due to the high permeability of the strata and this is instantaneous in comparison to the variation due to rainfall. This recovery can be interpreted as a steady state drawdown and the Dupuit-Forcheimer equation (Ref. 2) can be used to calculate permeability between different monitoring wells. When this analysis is carried out it is found that the aquifer has a permeability of 1.34×10^{-3} m/s for a well that fully penetrates the aquifer which is 5 m thick. This agrees well with the falling head tests which tests a small volume of the aquifer close to the well. However the total thickness of the limestone aquifer and the pumping well is a partially penetrating well. When the analysis is carried out for a partially penetrating well with a variable aquifer thickness between 52 and 15 m thick, the range in hydraulic conductivity values are 5.81×10^{-4} m/s to 1.34×10^{-3} m/s respectively. It seems likely that the valleys of the model area have high hydraulic conductivity than elevated areas as a result of dissolution of the limestone by rainfall. Therefore in the groundwater model a value of 1×10^{-3} m/s is used in the valley whereas 1×10^{-4} m/s is used in the upland areas. In the vicinity of the site (valley) the hydraulic conductivity is taken to be 1×10^{-3} m/s.

3. STEADY STATE MODEL

The groundwater modelling code Visual MODFLOW Version 4.1 is a numerical model, which solves groundwater flow equations by finite difference. The MODLOW code was first developed by the United States Geological Survey and has become the industry standard groundwater model. Inherent in the MODFLOW approach is the assumption that the aquifer can be modelled as a continuum and the aquifer material behaves as porous media where Darcy's Law is valid. Such an assumption may not always be valid for a fractured aquifer with potentially large dissolution voids such as the limestone present in Monaghan. MODFLOW may give a good representation of groundwater flow at a large scale (10s of metres) but will not be a good model of the fracture networks and dissolution features on the metre scale. The flow on the fracture scale will be more similar to that of surface water such as that in rivers.

Steady state calculations have been carried out using MODFLOW. Steady state modelling takes no account of groundwater variation in the short term such as might occur with an individual rain fall event but rather models the average flow state of the aquifer. The steady state model is calibrated to the existing groundwater levels. The effect of temporary

construction works can be modelled by inserting pile wall elements and groundwater lowering boreholes into the model.

3.1 Baseline Calibration

The average of the groundwater levels and river stage level collected in the monitoring of 22 September and 24 October 2006 were used to calibrate levels in the vicinity of the site. No regional groundwater data has been made available so it is not possible to calibrate the model for the wider area.

3.1.1 The River Shambles

A sensitivity analysis on the conductance of the River Shambles (the degree of hydraulic connectivity between the river and aquifer) was carried out and a value of 432 m^2/day determined to give a good calibration. This is quite a high value but would not be unexpected with such a permeable aquifer with interbedded layers of clay and gravel above it.

3.1.2 Other Surface Water Features

Other water features have been identified from the 1:50,000 topographic map. These are:

- Peter's Lake – 400 m north of the site.
- Mullaghadun Lough – 800 m to the north-west of site.
- Crannog Lake – 500 m to the south-west.

No information is available on the stage levels of these features but it is assumed to be their elevation on the topographic map. The features have been modelled with a lower conductance of 288 m^2/day although no specific data is available to enable calibration.

3.1.3 Recharge

An effective rainfall of 2 mm/day has been estimated from an annual effective rainfall of 700 mm/year based on approximately 1200 mm/year average rainfall (data obtained from the Irish Meterological Service website).

3.1.4 Ground Model

The ground model was generated using the topographic information given on the 1:50,000 topographic and geological map and ground investigation data. Generally Carboniferous Limestone underlies the whole area and the valley of the River Shambles is infilled with a mixture of clay, peat and gravel deposits.

In MODFLOW these superficial deposits are represented by a thin layer of clay upon gravel. The input hydraulic conductivity's for these layers are typical literature values for such materials [Ref. 1]. **Table 2** summarises the model inputs for hydraulic conductivity.

Table 2: Hydraulic Conductivity's used in Steady State Model

Material	Hydraulic Conductivity (m/s)	
	Horizontal	Vertical
Clay	1.0×10^{-6}	1.0×10^{-7}
Gravel	0.05	0.005
Valley Floor Limestone	0.001	0.0001
Limestone in Elevated Areas	0.0001	0.00001

4. DEWATERING DURING CONSTRUCTION

The assessment has been undertaken on the basis that the proposed method for constructing the basement will be to form a secant pile wall around the perimeter of the basement and de-water the interior before excavation and formation of the basal slab. This will require lowering the groundwater table to the base of the excavation so that it does not become flooded. This groundwater lowering can be carried out by pumping from a single pumping well or a number of wells. In the case of the site at Monaghan the groundwater table must be lowered to at least 44 mAOD, i.e. a drawdown of approximately 9 to 10 m. To assess the practicality of this, the first assessment has been undertaken by modelling the de-watering using a single well in the centre of the excavation. The MODFLOW steady state model has been used for this situation and a cross-section of the proposed pile wall is given in **Figure 6** as an illustration. **Figure 7** shows the locations of the observation points DW1 to DW3 in the model. The pumping rate was increased incrementally to 825 l/s when the groundwater level within excavation was lowered to 45.34 mAOD at DW2.

Table 3: Drawdown inside the excavation pumping from a single well at 825 l/s

Well/Point	Design Level (mAOD)	Model Level (mAOD)	Design – Model (m)
DW1	44	45.815	1.815
DW2	44	45.340	1.340
DW3	44	45.666	1.666

Unfortunately it was not possible to increase the pumping rate further as the model did not converge. This is probably the result of dewatering of model cells around the pumping well and very high calculated groundwater gradients. To further increase the pumping rate a model was run with five wells pumping at the edges of the excavation on the inside of the pile wall. It was found that a pumping rate of 225 litres per second in three pumping wells (PW1(2), PW1(3) and PW1(4)) and 250 litres per second in two pumping wells (PW1(5) and PW1(6)) was required to achieve the necessary drawdown. The total abstraction volume is 1175 litres per second.

Although the pile wall provides some degree of cut-off to groundwater flow into the investigation there will still be a significant level of drawdown outside the wall of the excavation. **Table 4** shows the calculated groundwater levels at the previous observation points. As can be seen from the table between approximately 1.6 and 3.2 m of drawdown would be expected outside of the pile wall.

Observations from site and anecdotal evidence would suggest that the car parking and hardstand areas around the shopping centre have been founded on the alluvial deposits.

These alluvial deposits contain a mixture of peat, clay and gravels. The thickness of peat is up to 10 m in some locations. Lowering the groundwater table in this area by 1 to 2 m is likely to cause significant settlement within the peat, clay and gravel horizons and may cause settlement of the structures founded on these deposits. This will be more pronounced where a significant thickness of saturated peat is present. It is expected that the buildings are constructed onto the limestone bedrock, and, as such are unlikely to be impacted by dewatering. However, if this is not the case, then pumping at these high rates does have the potential to result in some settlement of these buildings.

Table 4: Results of Groundwater Lowering Simulation on OBHs Outside Pile Wall.

Observation Point Name	Location	Level of Measurement	Model Without GW Lowering (mAOD)	Model With GW Lowering (mAOD)	With – Without (m)
OBH1	Between Shopping Centre & Proposed Basement	Base of Shopping Centre Basement	53.21584	51.30077	-1.91507
OBH1	Between Shopping Centre & Proposed Basement	Base of Proposed Basement	52.75484	50.83968	-1.91516
OBH3	West side of church	Base of Proposed Basement	52.50879	49.28738	-3.22141
OBH3	West side of church	Base of Church Basement	dry	dry	dry
OBH4	North side of proposed basement	Base of Proposed Basement	52.8273	49.89231	-2.93499
OBH5	South side of proposed basement	Base of Proposed Basement	52.58564	50.94798	-1.63766

4.1 The Effect of the Secant Pile Wall Cut-Off

Running the same steady state model for groundwater lowering (pumping at a combined rate of 1175 l/s) but without the pile wall makes it possible to determine the effectiveness of the pile wall as a cut-off. **Table 5** shows the results of removing the pile wall on the observation points within the excavation. It can be seen that the water level would rise by approximately 8 m with the result that pumping at 1175 l/s would not be sufficient to lower the groundwater table to the desired level and that a higher pumping rate would be required which is not considered a realistic option. Therefore the installation of the secant pile wall will be beneficial in reducing the overall volume of water to be dewatered during construction.

Table 5: Drawdown inside the excavation pumping from five wells at a combined abstraction rate of 1175 l/s with no pile wall

Well/Point	Pile Wall (mAOD)	No Pile Wall (mAOD)	Wall – No Wall (m)
DW1	43.51731	49.9683	6.45099
DW2	42.68804	48.31735	5.62931
DW3	42.69294	50.74142	8.04848

4.2 Groundwater Lowering System Design

It may be possible to reduce the required pumping rate from the excavation by placing wells at the perimeter of the excavation however experience has shown [Ref. 2&3] that the permeability of the ground encountered on site is probably on the upper range of what is possible by two stage well points or deep wells. The high permeability of ground coupled

with the recharge boundary of the river close by may make inflows to the excavation excessive.

The upper economic limit for the use of a deep well or well point system is of the order of 5×10^{-3} m/s[Ref. 2]. The pumping costs of dealing with soils of greater permeability are generally uneconomic. In such high permeability soil, exclusion methods may offer a more cost-effective expedient. Consideration should therefore be given to alternative dewatering scheme designs such as a deeper secant pile wall or wet excavation or grouting of the limestone floor of the basement.

5. MODELLING STORM EVENTS

The constant rate test was carried out during a large storm event during a period of above average rainfall and fluctuations in groundwater levels were recorded (0.7 m) over the timescale of a few days. Information from the Met Office of Ireland indicates that such a rainfall event (26.7 mm in one day) whilst being a heavy storm has a return period of less than 6 months. Therefore the groundwater level rise seen in such a storm is likely to be more significant than the steady state changes seen over longer time periods.

6. LIMITATIONS

- No information has been made available for the hydrogeological properties of the aquifer in the areas surrounding the site. This has been assumed based on a karstic limestone geology and information taken from the 1:50,000 topographic map of the area.
- A water features survey has not been made available for this work.
- MODFLOW is a continuum model, which assumes that aquifer materials can be modelled as porous media using Darcy's law. In highly Karstic aquifers this assumption may not be valid.
- Sensitivity analysis on the model parameter values and the impact of differing storm events have not been examined

7. CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

Based on the modelling work completed, it is reasonable to conclude the following:

- The dewatering that will be required to construct the basement as currently designed, even with the secant pile wall in place, will present a significant dewatering challenge due to the adverse ground conditions beneath the site and also the recharge capabilities of the adjoining River Shambles.

- Pumping from a single abstraction point is not considered a viable option as the level of pumping that will be required to lower groundwater levels for the dewatering operations has the potential to affect both local groundwater levels and the River Shambles. Increasing the number of abstraction points will likely lower total water abstraction rate.

- Additional work is necessary in order to determine the optimum dewatering design balancing construction practicality and cost while also ensuring that there are no offsite impacts on either local groundwater levels or the River Shambles.

7.2 Recommendations

In determining the optimum dewatering design it is recommended that the following items should be considered by the Contractor:

- How many abstraction points will be required to lower the water levels on-site in a manner that will not impact on surrounding lands or the River Shambles?

- Is there scope to revise the current design such as increasing the depth of the secant pile wall in order to reduce the dewatering requirements?

- How can the works be sequenced in order to minimise the area that would need to be dewatered at any given time?

- How can the works be programmed so that the time to construct the basement (duration) and construction season reduces the potential impacts from storm events?

- What criteria are the Local Authority likely to stipulate with regards to discharging water from the site into the River Shambles during the construction phase?

- Would alternative dewatering scheme designs such as wet excavation or grouting of the limestone floor of the basement be more economically viable?

To assist in providing clarification to some or all of these points, the following additional work could be undertaken:

1. Modelling

The initial dewatering model indicates that a single well point would require significant dewatering to reduce the groundwater level to allow construction. This will have an impact on the surrounding ground as settlement occurs through dewatering. An initial model utilising 5 well points indicates that this is likely to have a lower dewatering

rate, with a subsequent smaller impact on the surrounding ground. Further modelling of dewatering scenarios must be undertaken to gain optimum conditions from a design perspective. This must include sensitivity analysis in the following parameters:-

- Number of abstraction boreholes
- Deeper secant pile wall
- Dewatering smaller working areas and constructing the basement in smaller sections
- Varying the permeability of the limestone with depth

Further modelling work must also be carried out to determine the effect of storm events on groundwater levels. It may be possible to use MODFLOW to generate transient simulations of the groundwater response as a result of storm events recorded on site but depending on the initial results, different software packages may need to be utilised in order to accurately model the kind of transient behaviour observed.

2. Data collection

Additional data is required as part of this modelling exercise as follows:-

- The water feature survey must be completed – this must include flow data from the River Shambles and rainfall intensity over time.
- Any additional construction details that can be obtained on the structures surrounding the site.
- A geological review of the deeper limestone should be undertaken through desk study research of borehole data available from the public record.

3. Field Work

This modelling will have to include a number of assumptions for the condition of the aquifer below the current investigation boreholes. As this will have a significant impact on the construction of the basement, a confirmatory borehole and testing will be required to ensure the parameters modelled are realistic.

8. REFERENCES

1. Freeze and Cherry, 1979: Groundwater.

2. Cashman, P.M., & Preene, M., 2001: Groundwater Lowering in Construction – A practical Guide.

3. Preene, M., Roberts, T.O. L., Powrie, W. and Dyer, M.R., 2000: Groundwater Control – Design and Practice. Construction Industry Research and Information Association, CIRIA Report C515, London.

Figure 1: Monitoring and Pumping Well Locations

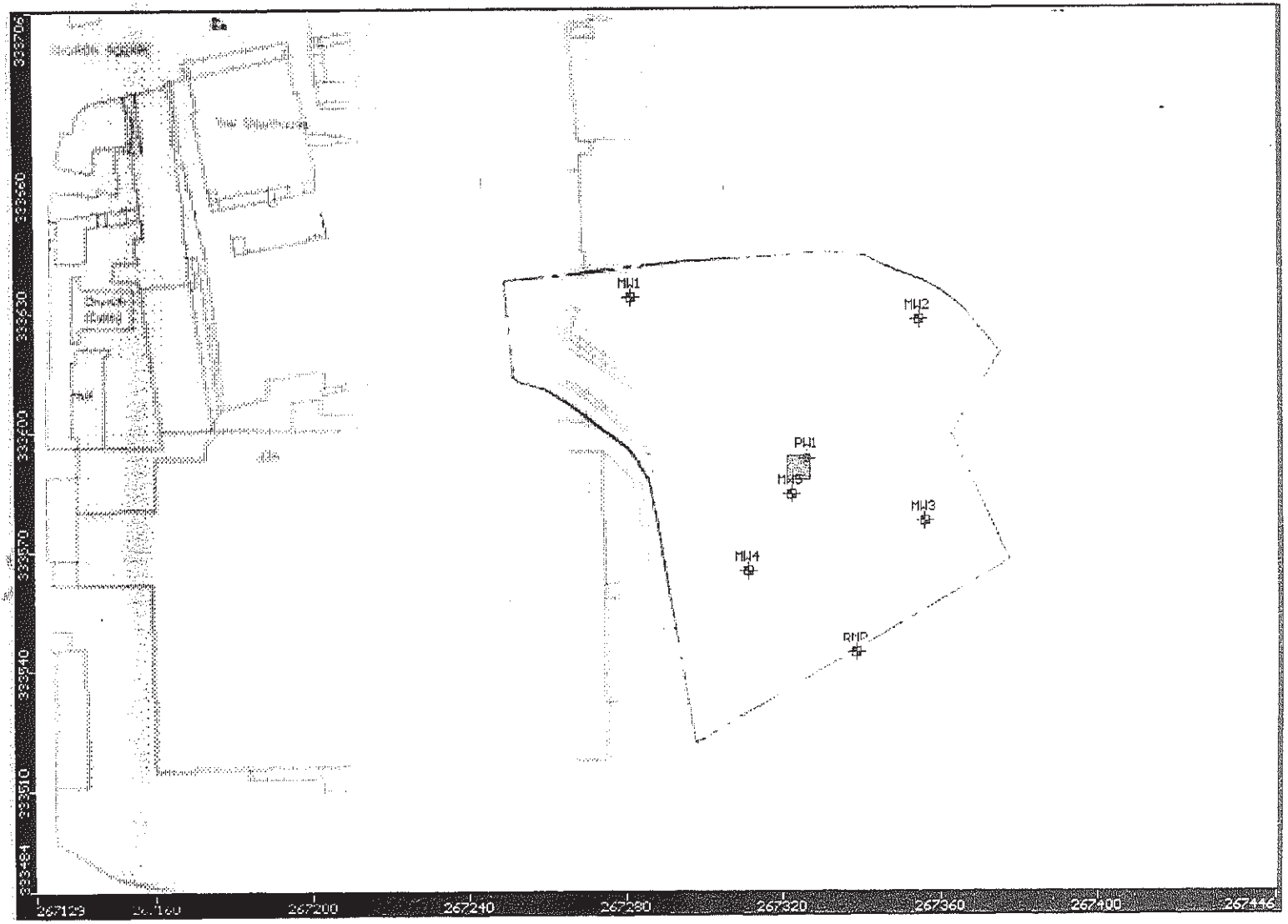


Figure 2: Groundwater Levels in the Limestone between 21st September and 31 October 2006

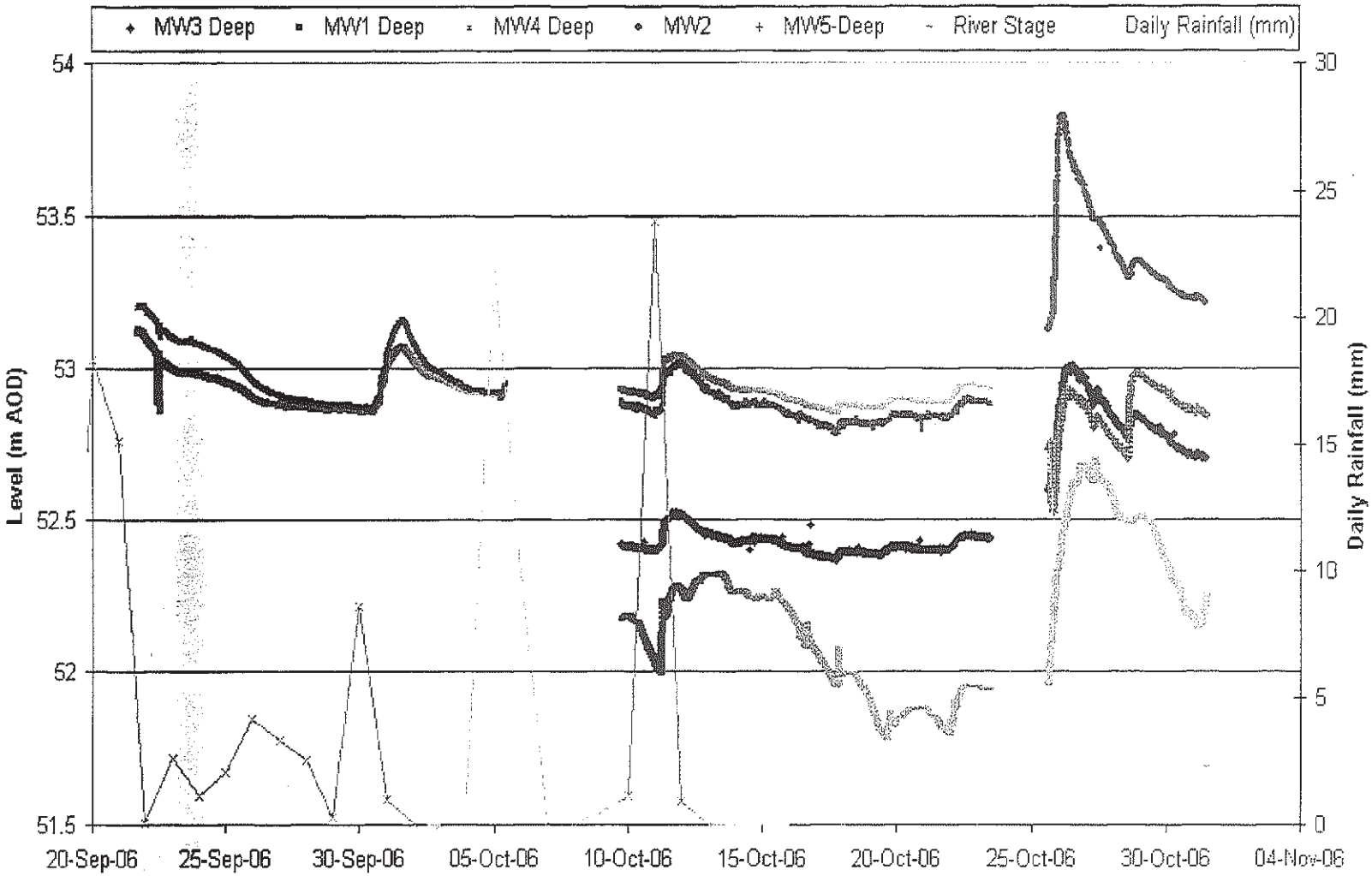
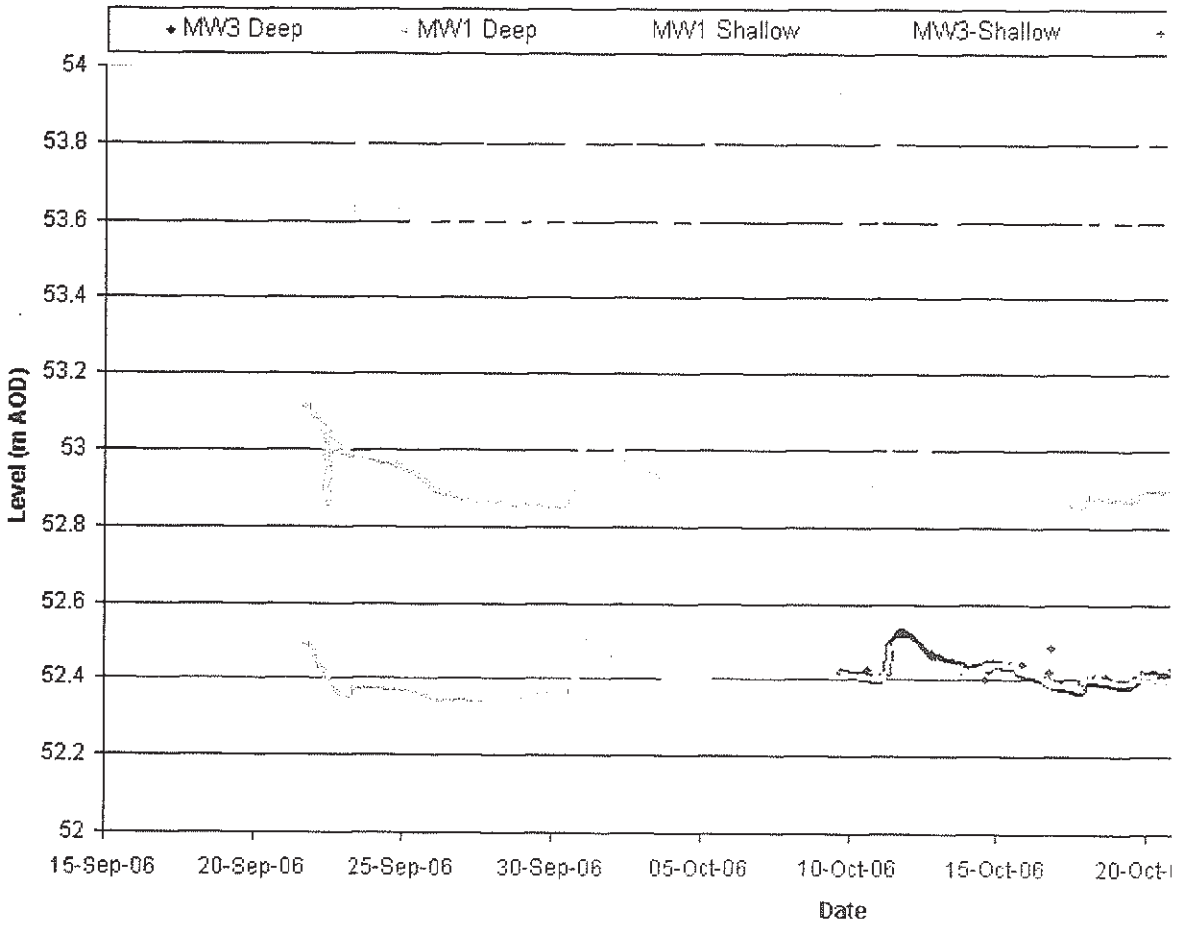


Figure 3: Groundwater Levels in the Limestone and Gravels



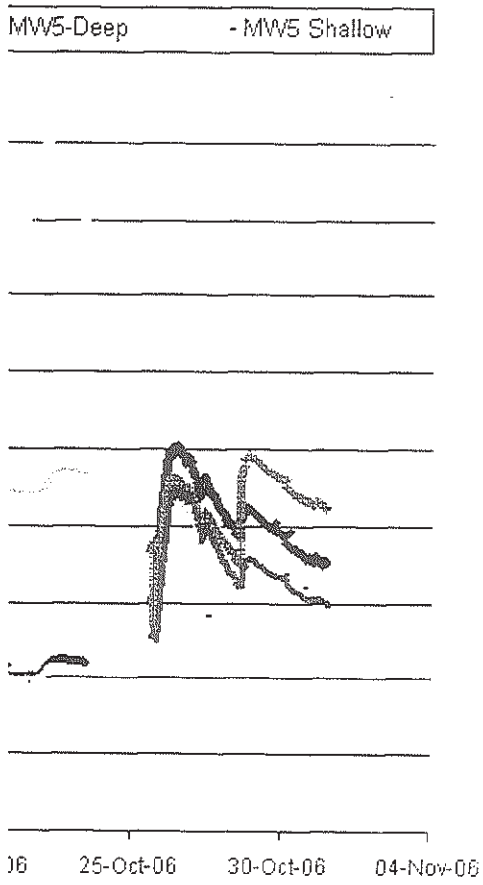

MW5-Deep
- MW5 Shallow
)6
25-Oct-06
30-Oct-06
04-Nov-06

Figure 4: Groundwater Levels during Constant Rate Test in Observation Boreholes

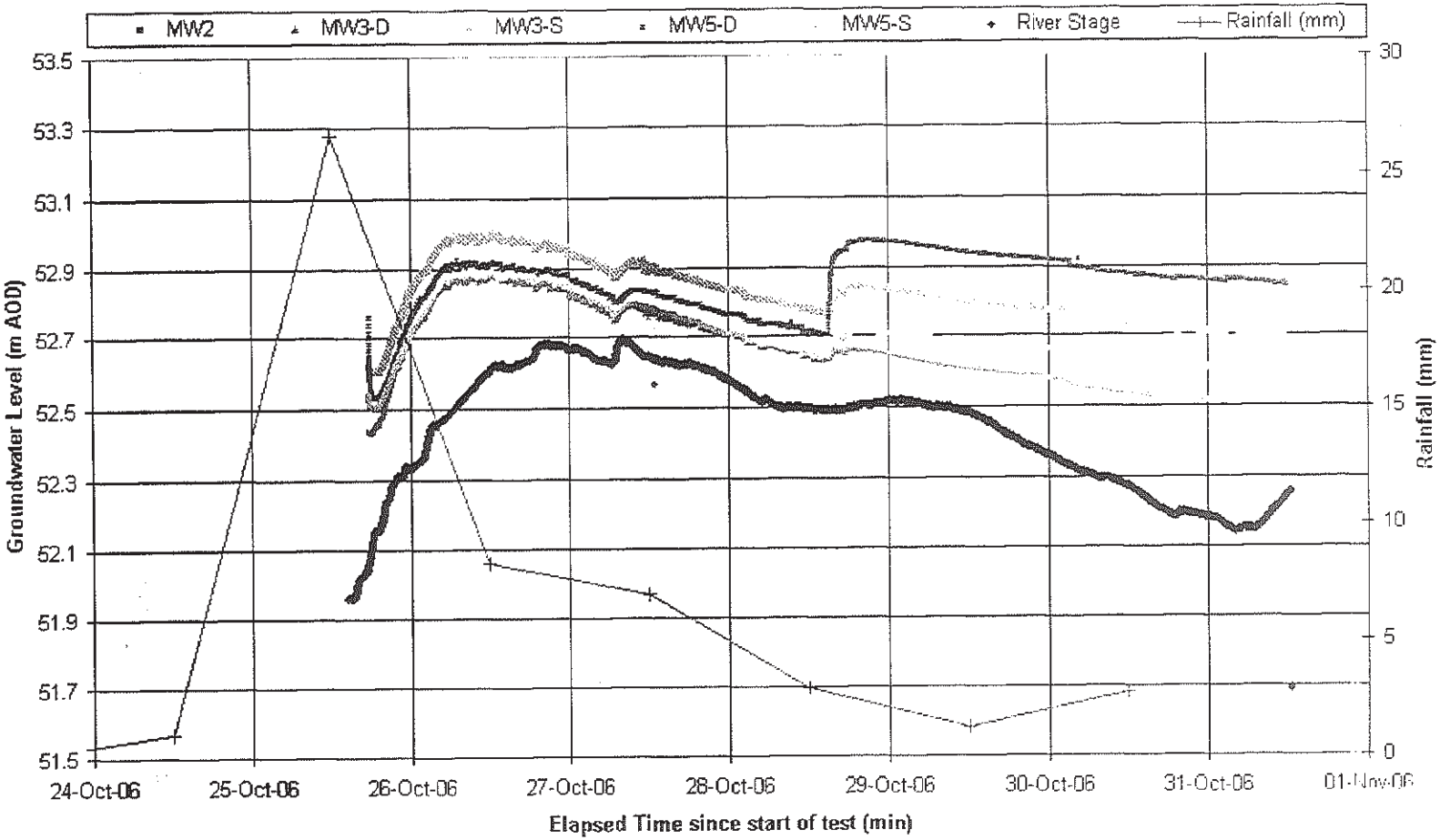


Figure 5: Drawdown in the Pumping Well during Constant Rate Test

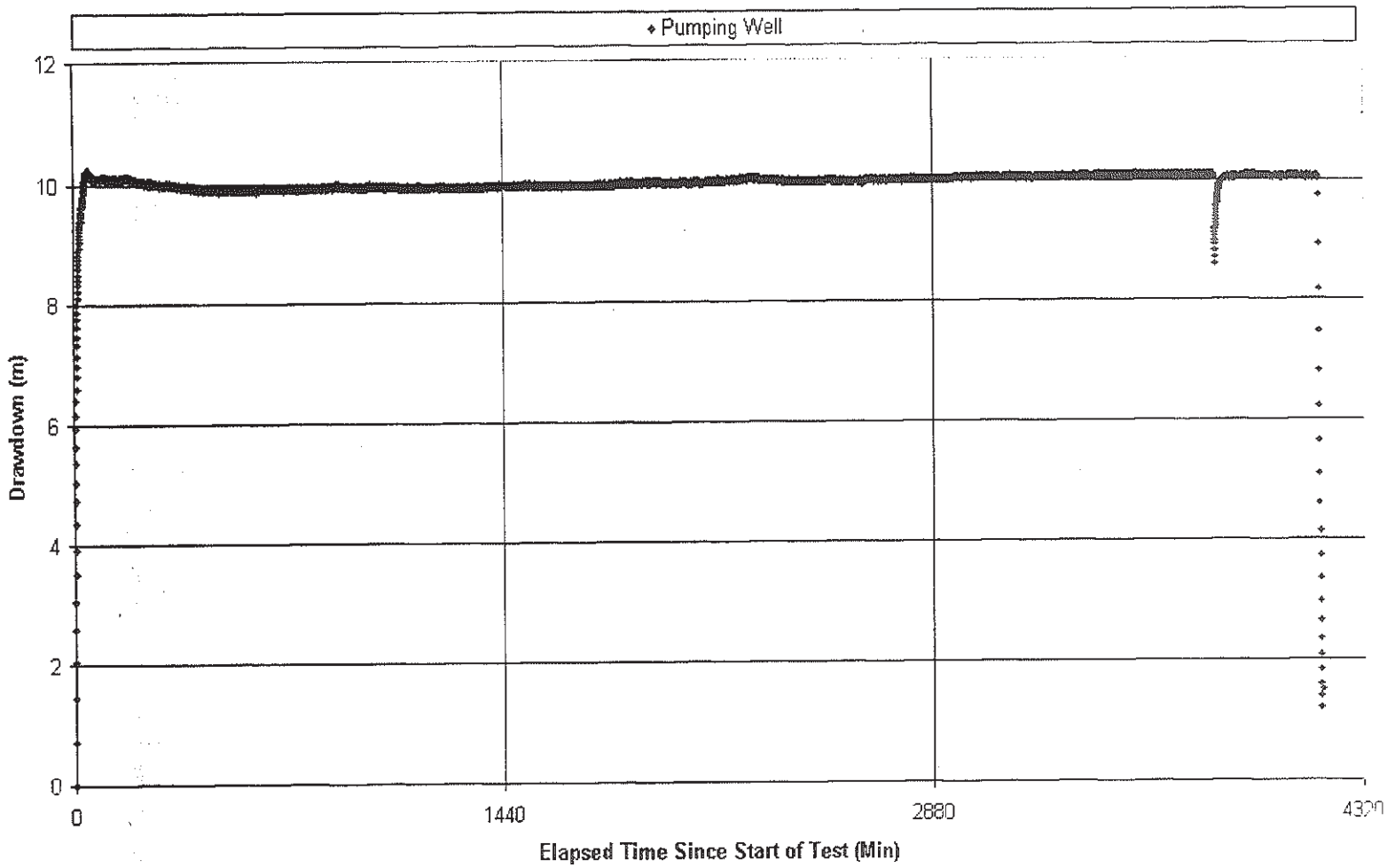


Figure 6: Cross-section of Proposed Piles

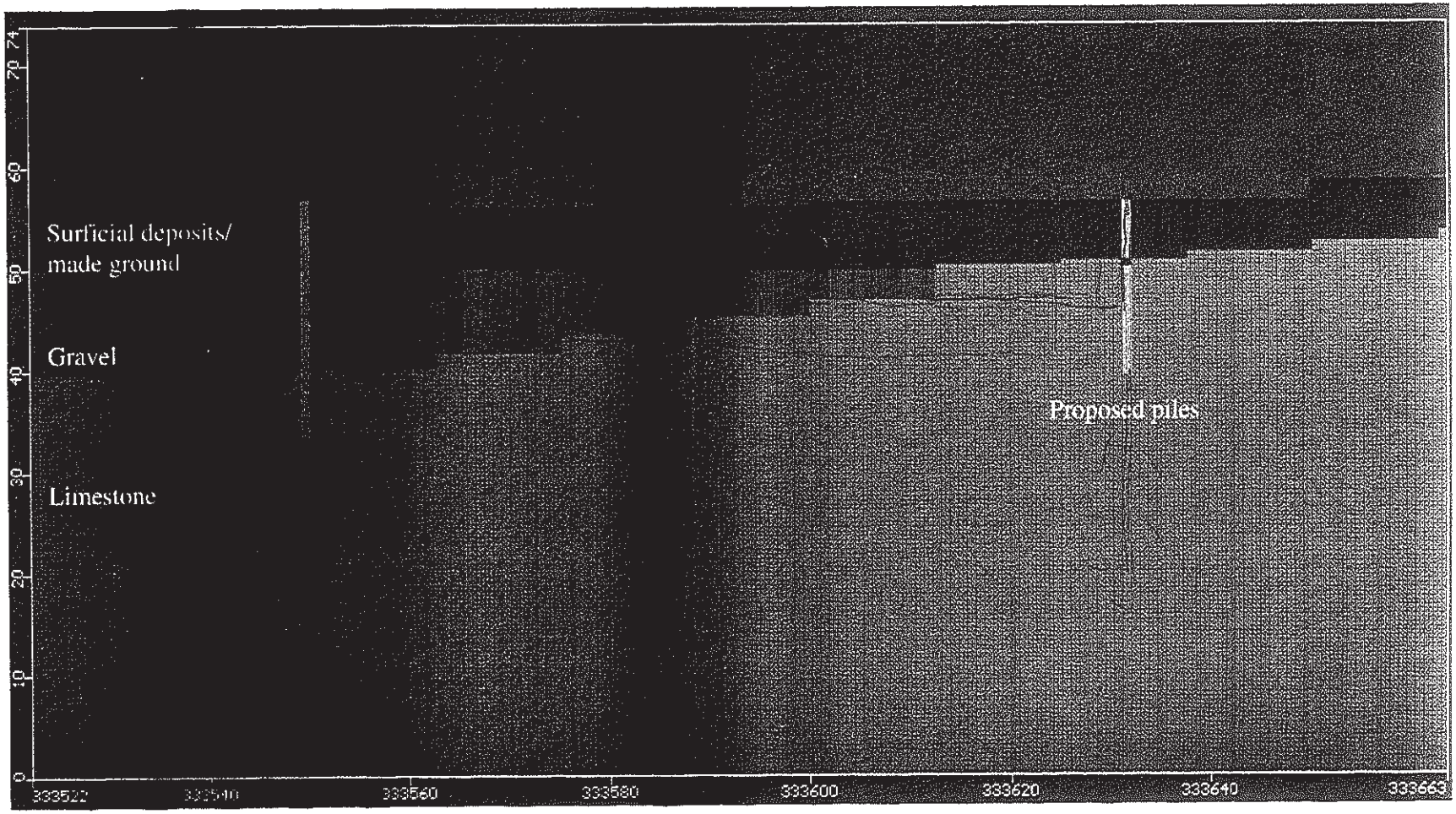
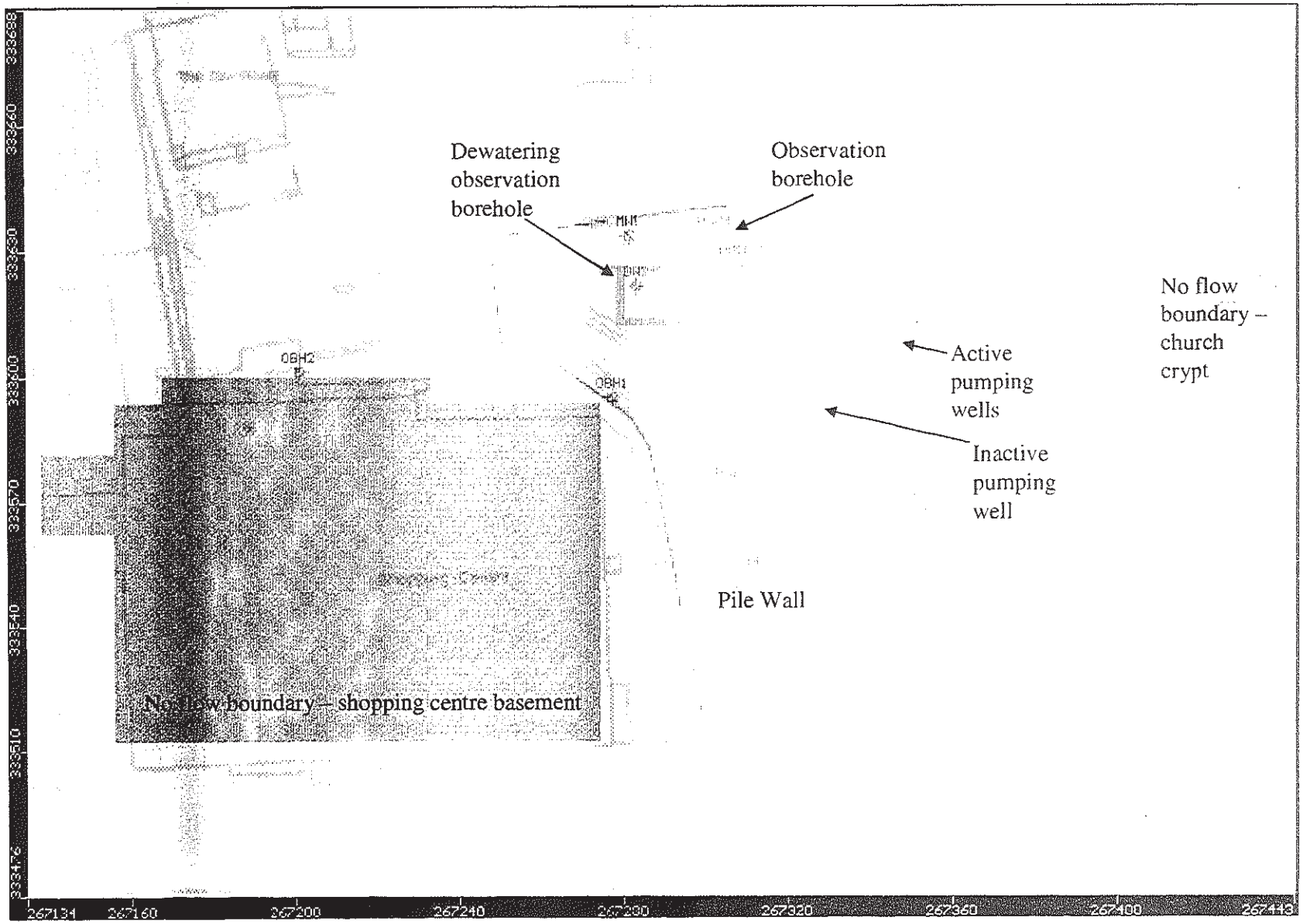


Figure 7: Location of monitoring points in the groundwater lowering model



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Proposed Mixed Use Development
Rooskey, Monaghan Town, Co. Monaghan
P.T. McWilliams

Webber Associates
Consultant Geotechnical Engineers

July 2007

Proposed Mixed Use Development
Rooskey, Monaghan Town, Co. Monaghan

Hydrogeology Assessment

July 2007

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1.0 INTRODUCTION

1.1 General

Monaghan County Council is redeveloping the Lower Courthouse Carpark, Monaghan Town as a mixed use development. Part of this development includes a three tiered basement excavation. Clarke Engineering Ltd were appointed as developer for the project who in turn retained the services of P. T. McWilliams as contractor. P.T. McWilliams has asked Webber Associates (UK) Ltd (WA) to provide a supplementary hydrogeological assessment of the site.

The aim of this report is to summarize the WA designed hydrogeological investigation carried out on site, comment on their results and possible implications for groundwater entry during excavation of the basement

1.2 Description of the Project

The site is situated in Rooskey, Monaghan Town, Co. Monaghan, Ireland. The site is an approximately one acre site that gently slopes from the north (+56 mOD) to the south (+53 mOD). The site is bound by the courthouse and various retail units to the north and east, and by a Tesco Shopping Centre to the west. The site is adjacent to the River Shambles which flows eastwards through a man made channel along the southern boundary of the site.

A surface level car park currently occupies the site. The proposed development comprises 10 blocks of 4-storey retail and residential units enclosing a central courtyard. Most of the proposed development will be underlain by a three tiered basement. The excavation and construction of this basement is the scope of this report.

1.3 Site Investigations and Site Assessments

Several site investigations and ground and groundwater assessments have been carried out on site, including the following which investigated groundwater and permeability:

- MWH Monaghan Hydrogeological Assessment Report RT-NN-1257/01 (included 4 number Falling Head Tests and a Constant Rate Pumping Test) (2006)

- Malone O' Regan Environmental Services Ltd, Monaghan Hydrogeological Assessment Report RT-NN-1257/02 (2007)

- Malone O' Regan Environmental Services Ltd, Monaghan Hydrogeological Assessment Report – Impacts of Temporary Construction Works on Groundwater. RT-NN-1257/02 (2007)

The results and findings of these reports indicate very high permeabilities for both overburden and rock. On this basis, substantial ground water entry into the basement excavation was predicted which would make it difficult if not impossible to construct the basement.

In order to assess this problem further, a supplementary site investigation was designed by WA and carried out by Irish Geotechnical Services Ltd (IGSL) in May 2007. The purpose of the site investigation was to assess the ground and groundwater conditions specifically for basement design and excavation. This investigation included:

- 1 number cable percussion borehole
- 6 number rotary drilled boreholes
- 6 number standpipe piezometer installations
- 6 number variable head permeability tests
- 8 number Packer Permeability tests
- 1 number pump test

Rock cores were retained for logging and laboratory testing. The following tests were scheduled by WA.

- Uniaxial Compressive Strength
- Point load testing

2.0 GROUND CONDITIONS

2.1 Stratigraphic Profile

The site investigations indicate that two different stratigraphic profiles are present on site. In the northern section of the site, rockhead is typically found about 5 m below ground level. This is overlain by Glacial Till. Surface level is about 55 mOD.

The southern section of the site is differentiated by a sudden drop in rockhead level to approximately 15 m below ground level. This section of the site has been upfilled by 3 m as it was once marshland. This made ground overlies a thick layer of peat over Glacial Till. Surface level is about 53 mOD.

Summaries of these profiles are presented in Table 2.1 and Table 2.2.

Table 2.1 Summary of Ground Conditions in northern section of the site

Stratum	Description	Depth to Base		Thickness	
		min	max	min	max
Made Ground	Tarmacadam and fill (cobbles and boulders)	1.5	3	1.5	3
Peat	Fibrous - found in one borehole	3.5		2	
Glacial Clay	Silty sandy clay	3.4	5.6	0.4	2.6
Glacial Gravels	Silty sandy gravels	4	6	1	4.1
Limestone	Moderately to highly weathered, fractured, clay infill	4.5*	9.4*	Base not seen	

* Rockhead

Table 2.2 Summary of Ground Conditions in southern section of the site

Stratum	Description	Depth to Base		Thickness	
		min	max	min	max
Made Ground	Tarmacadam and fill (cobbles and boulders)	3.2	4.5	3.2	4.5
Peat	Fibrous	7.6	11.2	4.4	6.7
Glacial Clay	Silty sandy clay	9	13.5	1.4	2.5
Glacial Gravels	Silty sandy gravels	10	17.7	1	4.2
Limestone	Moderately to highly weathered, fractured, clay infill	12.5*	17.7*	Base not seen	

* Rockhead

2.2 Groundwater

Ground water was encountered in all exploratory holes. Water strikes were typically encountered between 1.7 m and 4.2 m below ground level.

Standpipe piezometers were installed in six boreholes. A summary of levels are tabulated below.

Table 2.3 Summary of Piezometer Levels

Borehole	Surface Level (m OD)	Depth to Water (m bgl)
B1	55.2	2.5
C	55.6	2.8
D	55.5	2.6
E	55.6	2.8
F	53.2	1.2*
G	53.2	0.6*

* Results not available at time of writing report, highest recorded strike listed

3.0 HYDROGEOLOGICAL TESTING

3.1 Variable Head Tests

Variable head tests were carried out in the glacial gravels and weathered rock in order to assess permeability. The available results are tabulated below (Table 3.1). Dual tests were carried out where possible to confirm permeability readings. Rising and falling head tests indicate permeabilities in the range 10^{-3} to 10^{-4} m/s.

Table 3.1 Summary of Variable Head Tests

Exploratory Hole no.	Ground level (mOD)	Material in Test Zone	Level for Tests (mOD)	Initial Ground water level (mOD)	Permeability from Falling Head Tests (m/s)	Permeability from Rising Head Tests (m/s)
C	55.6	Gravels	51.32	52.64	$1.17x10^{-3}$	
D	55.5	Gravels	51.11	52.78	$1.14x10^{-3}$	$1.14x10^{-4}$
F	53.16	Limestone	35.32	52.72		$2.26x10^{-4}$

3.2 Packer Tests

Eight packer tests or Lugeon tests were carried out in the limestone at specific levels to assess the extent of the fracturing within the limestone and hence its permeability. The packer test gives a measure of the acceptance by in-situ rock of water by pressure. The available results are listed in Table 3.2. The results indicate permeability in the range 0.5 to 10 $x10^{-5}$ m/s. Most results are in the range 1 to 2 $x10^{-5}$ m/s.

Table 3.2 Summary of Packer Tests

Exploratory Hole no.	Ground level (mOD)	Material in Test Zone	Level for Tests (mOD)	Initial Ground water level (mOD)	Method 1*	Method 2**
B1	55.2	Limestone	42.4 – 41.4	52.74	$1.12x10^{-5}$	$8.86x10^{-6}$
			44.2 – 43.2	52.74	$6.35x10^{-6}$	$5.24x10^{-6}$
C	55.6	Limestone	39.8 – 38.8	53.11	$2.32x10^{-5}$	$1.9x10^{-5}$
			42.1 – 41.1	53.02	$3.18x10^{-5}$	$2.63x10^{-5}$
D	55.5	Limestone	42.0 – 41.0	52.85	$4.96x10^{-5}$	$3.97x10^{-5}$
			44.0 – 43.0	52.85	$1.89x10^{-5}$	$1.52x10^{-5}$
E	55.6	Limestone	41.6 – 40.6	52.96	$1.04x10^{-4}$	-
F	53.16	Limestone	31.92 – 30.92	52.8	$4.83x10^{-6}$	$3.63x10^{-6}$

3.3 Well Pump Test

A four day field pumping test was carried out on site. The pressure distribution was measured by piezometers on radial lines away from the well borehole. Previously excavated boreholes were also monitored for drawdown. The pumping test yielded a 1.3 l/s for a drawdown in the well of 7 m.

4.0 IMPLICATIONS OF PERMEABILITY RESULTS

An in-depth and accurate investigation and assessment of the sub surface's various permeabilities are required for the effective construction of the proposed basement. The initial investigations and reports on Monaghan once reviewed revealed that discrepancies had occurred. It was noted that the positions of the monitoring piezometers were mostly in gravels rather than rock. Any discrepancies within the site investigation during permeability testing can lead to the errors in the assessment of permeability to a factor of ten.

Further discrepancies were also noted in the calculations for drawdown, yield and inflow. Permeability of the gravels and limestone were given as 10^{-3} m/s but the well produced 10 m of drawdown for a yield of 5 l/s. This data is contradictory, either permeability is lower or the well was very inefficient. Groundwater modeling predicted an inflow of 825 l/s, which implies 160 number wells, would be required for dewatering. This is almost certainly wrong because the model used very high permeabilities, i.e. limestone k_h of 10^{-3} m/s and gravel k_h 5 x 10^{-2} m/s.

It was on this basis that a supplementary investigation and assessment was carried out. Rising and falling head tests in the gravels indicate permeabilities in the range of 10^{-3} to 10^{-4} m/s although the extent of the gravels is limited. The gravels may be related to the weathered surface of the limestone.

The limestone's permeability is in the range of 10^{-5} m/s. This is a typical moderately permeable rock. The consistency of the results (all over short, 1m test lengths) indicates that jointing is probably widespread but joint apertures are probably small. The highest permeability recorded was associated with the poorest quality rock in borehole E in the north west corner of the site which extended to 20 m depth.

The drawdowns observed in boreholes around the site during the pumping test were plotted as contours. The contours suggest an ENE – WSW elongation consistent with a feature within the limestone bedrock. This may have implications for settlement outside the site. General information suggests that the ground is at a higher elevation

to the north of the site and building are probably founded on the limestone above the water table. Risk of settlement damage in these areas should therefore be limited.

Small drawdowns, around 0.1 m, were observed at other locations including within the peat. It is not clear whether these are due to the pumping test or other factors such as changing river levels or generally drainage.

The southern section of the site may be vulnerable to dewatering settlement due to the depth of peat but buildings are generally piled in this area. This area needs to be investigated further and monitoring of water levels and ground settlement instigated. Recharge is not appropriate due to moderate permeabilities in the rock.

The effects of the temporary dewatering should be limited to the area immediately adjacent to the basement and should not impact on the adjacent buildings. However, possible vulnerable buildings will need to be identified and monitored.

5.0 PROPOSED MEASURES

Because of potential high permeabilities in the gravels and local stability a cut off to the rock is required. A deep cut off is considered to be inappropriate due to moderate rock permeability and the difficulty in forming a deep cut off in strong rock. A cut off generally penetrating 3 m into the rock (or less if "solid" rock is encountered) is a more effective solution. This will leave a substantial rock face exposed on one side of the excavation.

The excavation can be constructed using deep dewatering wells installed within the structure. Design of a dewatering scheme would be difficult to design in detail due to the variable conditions across the site. However, based upon experience and simple empirical calculations six to eight wells yielding 5 l/s with two wells at 10 to 20 l/s would probably suffice. Total flow for the site would be between 30 and 50 l/s.

Wells should be located inside the retaining walls, however on the NE side piles will be short and there will be an exposed face of rock.

There are two main options for the permanent works design.

1. Design the structure to resist full uplift pressure
2. Design it to be permanently drained.

Due to the significant flows of groundwater likely to be encountered and the difficulties of getting a long term abstraction licensed for such flows, the drained option is not recommended.

6.0 CONCLUSIONS

Ground water entry is expected during excavation of the basement in Monaghan. Exact flow rates are difficult to estimate due to the highly variable ground conditions on site. However, flows between 30 l/s and 50 l/s are anticipated. Groundwater entry could be temporarily controlled using deep wells within the confines of the excavation. The results of hydrogeological testing carried on site indicate that the effect of the temporary dewatering i.e. settlement, should be limited to the areas immediately adjacent to the basement and should not impact on the adjacent buildings.

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Monaghan Town Council
16 JUL 2007
Comhairle Baile Muineachain

The Planning Department
Monaghan Town Council
Dublin Street
Monaghan.

16th July 2007

Dear Sirs,

Re: Planning Application M.T. 06/75 DPT Mixed Use Development Ltd
Planning Condition 26.

We attach the following in connection with the above planning application condition.

Condition 26: Copy of the Hydrogeology Assessment

Yours sincerely

David Mole

Cc: Mr Kevin McNally

1. ack
2. copy to K. Mc Nally
3. " " TE
4. " " Planning
5. File

Registered in R.O.I. Company No: 396256. Registered Office: Church Hill, Clones, Co. Monaghan

Appendix

7b

IGSL Ground Investigation Factual Report

IGSL Ltd

Client: Monaghan County Council

Engineer: RPS Group

Monaghan Town – South Dublin Street and Backlands Regeneration Scheme - Ground Investigation

Project No. 22412

October 2021

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FOREWORD
The following conditions and notes on the geotechnical site investigation procedures should be read in conjunction with this report.

Standards
The ground investigation works for this project have been carried out by IGSL in accordance with Eurocode 7 - Part 2: Ground Investigation & Testing (EN 1997-2:2007). This has been used together with complementary documents such as BS 5930:2015 and BS 1377 (Parts 1 to 9) and the following European Norms:

- EN 1997-2 Eurocode 7: 2007 – Geotechnical Design – Part 2: Ground Investigation & Testing
- EN ISO 22475-1:2006 Geotechnical Investigation and Sampling – Sampling Methods & Groundwater Measurements
- EN ISO 14688-1:2018 Geotechnical Investigation and Testing – Identification and Classification of Soil, Part 1: Identification and Description
- EN ISO 14688-2:2018 Geotechnical Investigation and Testing – Identification and Classification of Soil, Part 2: Classification Principles
- EN ISO 14689-1:2018 Geotechnical Investigation and Testing - Identification & Classification of Rock, Part 1: Identification & Description

Reporting
This report has been prepared for Monaghan County Council and RPS and the information should not be used without prior written permission of either party. IGSL Ltd accepts no responsibility or liability for this document being used other than for the purposes for which it was intended. No responsibility can be held by IGSL Ltd for ground conditions between exploratory hole locations.

The engineering logs provide ground profiles and configuration of strata relevant to the investigation depths achieved and caution should be taken when extrapolating between exploratory points. No liability is accepted for ground conditions extraneous to the investigation points. Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction, mining works or karstification below or close to the site.

Boring Procedures
Unless otherwise stated, 'shell and auger' or cable percussive boring technique has been employed as defined by Section 6.3 of IS EN ISO 22475-1:2006. The boring operations, sampling and in-situ testing complies with the recommendations of IS EN 1997-2:2007 and BS 1377:1990 and EN ISO 22476-3:2005+A1:2011. The shell and auger boring technique allows for continuous sampling in clay and silt above the water table and sand and gravel below the water table (Table 2 of IS EN ISO 22475-1:2006).

It is highlighted that some disturbance and variations is unavoidable in particular ground (e.g. blowing sands, gravel / cobble dominant glacial deposits etc). Attention is drawn to this condition, whenever it is suspected. Where cobbles and boulders are recorded, no conclusion should be drawn concerning the size, presence, lithological nature, or numbers per unit volume of ground.

Rotary Drilling Procedures
Rotary drilling methods are used to recover very heavily over-consolidated glacial till and bedrock samples in line with Section 3.5 of IS EN 1997-2:2007 and IS EN ISO 22475-1. Open hole drilling methods (odex or symmetrix) are utilized to advance the drillholes through granular dominant superficial deposits, with coring in hard ('cemented') fine grained or cohesive glacial deposits and bedrock.

In-Situ Testing
Standard penetration tests are conducted by IGSL strictly in accordance with Section 4.6 of IS EN 1997-2:2007. The SPT equipment (hammer energy test) has been calibrated in accordance with EN ISO 22476-3:2005+A1:2011 and the Energy Ratio (E_r) is defined as the ratio of the actual energy E_{meas} (measured energy during calibration) delivered to the drive weight assembly into the drive rod below the anvil, to the theoretical energy (E_{theor}) as calculated from the drive weight assembly. The measured number of blows (N) reported on the engineering logs are uncorrected. In sands, the energy losses due to rod length and the effect of the overburden pressure should be taken into account (see IS EN ISO 22476-3:2005+A1:2011).

Groundwater
The depth of entry of any influx of groundwater is recorded during the course of boring or drilling operations. However, the normal rate of boring does not usually permit the recording of an equilibrium level for any one water strike. Where possible drilling is suspended for a period of twenty minutes to monitor the subsequent rise in water level. Groundwater conditions observed in the borings or pits are those appertaining to the period of investigation. It should be noted however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage conditions, tidal variations etc.

Soil Sampling
Three categories of sampling methods are outlined in EN ISO 22475-1:2006. The categories are referenced A, B and C for any given ground conditions and are shown in Tables 1 and 2 of EN ISO 22475-1:2006. Reference should be made to EN 1997-2:2007 for guidelines on sample class and quality for strength and compressibility testing. Samples of quality classes 1 or 2 can only be obtained by using Category A sampling methods.

Where appropriate Class 1 thin wall undisturbed tube samples (UT100) are obtained in fine grained soils and strictly meet the requirements of EN 1997-2:2007 and EN ISO 22475-1:2006. Soil samples for laboratory tests are divided into five classes with respect to the soil properties that are assumed to remain unchanged during sampling, handling transport and storage. The minimum sample quality required for testing purposes to Eurocode 7 compatibility (EN 1997-2:2007) is shown in Table A.

Table A – Details of Sample Quality Requirements

EN 1997 Clause	Test	Minimum Sample Quality Class
5.5.3	Water Content	3
5.5.4	Bulk Density	2
5.5.5	Particle Density	N/S
5.5.6	Particle Size Analysis	N/S
5.5.7	Consistency Limits	4
5.5.8	Density Index	N/S
5.5.9	Soil Dispersivity	N/S
5.5.10	Frost Susceptibility	N/S
5.6.2	Organic Content	4
5.6.3	Carbonate Content	3
5.6.4	Sulphate Content	3
5.6.5	pH	3
5.6.6	Chloride Content	3
5.7	Strength Index	1
5.8	Strength Tests	1
5.9	Compressibility Tests	1
5.10	Compaction Tests	N/S
5.11	Permeability	2

N/S – not stated. Presume a representative sample of appropriate size.

Samples recovered from trial pits or trenches meet the requirements of IS EN ISO 22475-1. It is highlighted that unforeseen circumstances such as variations in geological strata may lead to lower quality sample classes being obtained.

Engineering Logging

Soil and rock identification is based on the examination of the samples recovered and conforms with IS EN ISO 14688-1:2018 and IS EN ISO 14689-1:2018. Rock weathering classification conforms to IS EN ISO 14689-1:2018 while discontinuities (bedding planes, joints, cleavages, faults etc) are classified in accordance with 4.3.3 of IS EN ISO 14689-1:2018. Rock mechanical indices (TCR, SCR, RQD) are defined in accordance with IS EN ISO 22475-1:2006.

Retention of Samples

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material will be discarded. Unless a period of retention of samples is agreed, it is company policy to discard soil samples one month after submission of our final report.

1. INTRODUCTION

At the instruction of RPS, working on behalf of Monaghan County Council, IGSL has undertaken a programme of geotechnical site investigation works for the proposed regeneration project on Dublin Street.

This report relates to the geotechnical investigation works acquired during the 2021 ground investigation works. The geotechnical investigatory works included cable percussive boreholes, rotary coreholes, trial pits, slit trenches, infiltration tests, associated laboratory testing and surveying.

The field investigations were executed in accordance with BS 5930, Code of Practice for Site Investigations (2015) and EN 1997-2 Eurocode 7 Part 2 Ground Investigation & Testing. Chemical laboratory testing was conducted by Chemtest on samples selected by the Employer's Representative.

Traffic Management was implemented by IGSL in accordance with the "Department of Transport Traffic Signs Manual- Chapter 8 Temporary Traffic Measures and signs for Roadworks". All Traffic management was installed and removed under the supervision of an IGSL Engineer with a Solas/FÁS CSCS Card in Lighting, Signing and Guarding at Roadworks.

This report presents the factual geotechnical data acquired from the site investigation.

Figure 1: Site Location Plan (Google Earth Image 2021)

2.0 CONTRACT OUTLINE & OBJECTIVES

The scope of work for this project was performed in one phase.

The primary objectives of the works were as follows:

- Determine the composition, consistency and strength / stiffness of the superficial soils
- Recover samples for Geotechnical and Environmental laboratory testing in accordance with the requirements of the Employer's Representative
- Establish the rockhead elevation, weathering profile, discontinuity characteristics and strength of the bedrock
- Identify the location of existing services
- Ascertain Infiltration paraments

3. FIELDWORKS

3.1 General

The geotechnical investigation was carried out from July to September 2021and comprised the following:

- Cable Percussive Borehole
- Rotary Coreholes
- Trial Pits
- Slit Trenches
- Infiltration testing
- Associated soil sampling
- Setting Out & Surveying

The ground investigations were executed in accordance with BS 5930, Code of Practice for Site Investigations (2015), EN 1997-2 Eurocode 7 Part 2 Ground Investigation & Testing and the Engineers Ireland Specification for Ground Investigation & related documents (2nd Edition 2016)

3.2 Cable Percussive Boreholes

The cable percussion boreholes (200mm diameter) were sunk using a Dando 2000 rig and employed conventional cable tool boring methods as outlined in the Foreword.

Representative bulk disturbed samples were taken at approximately 1.00m intervals or change of stratum and double sealed in polyethene bags. Environmental samples were taken as directed by the Employer's Representative and these included glass jars, a glass vial and a plastic tub.

Standard Penetration Tests (SPT's) were performed in the boreholes in accordance with Section 3.3, Part 9 of BS 1377 (1990). The SPT measures the number of blows required by a 63 kg hammer falling through a drop height of 760mm to drive a cone or a split spoon a distance of 300mm through the soil. Prior to the commencement of the test, the cone or split spoon is driven an initial distance of 150mm into the soil and the number of blows for this penetration depth are recorded as the "seating blows". The subsequent blowcounts for each 75mm increment (300mm) of penetration are recorded and summated to give the 'N-Value' as reported on the borehole log. The seating and test blow counts are reported in brackets with the N-Value recorded accordingly (e.g. BH001 at 1.2m where N=06 (4,4,3,0,2,1). The Energy Ratio for the SPT Hammer used on the contract is 77.09%(SPT Hammer No: SA4).

Details of the soils (strata) encountered, SPT N-Values, samples recovered and chiseling durations (hard strata boring) are presented on the boring records in Appendix 1.

3.2 Rotary Core Drillholes

Rotary core drilling was carried out using a tracked Commachio Geo 205 rig. Open hole drilling (odex) was employed in the superficial deposits (overburden) with air mist coring in the bedrock units. The rotary drilling produced 78mm diameter cores and total core recovery (TCR) was generally excellent (100% in the majority of the runs).

Standard Penetration Tests (SPT's) were performed in selected drillholes and given the nature of the soils, a solid cone was used. It is noted that the SPT N-Values reported are the number of blows for 300mm increment penetration. These exclude the seating blow values, which represent the initial 150mm depth of penetration. Where partial penetration was achieved during testing, the number of blows is shown for the actual penetration depth achieved.

The cores were placed in 3m capacity timber boxes and logged by an IGSL engineering geologist. This included photography of the cores with a digital camera. Where rock core was recovered, a graphic fracture log is also presented alongside the mechanical indices. This illustrates the fracture state of the rock cores and allows easy identification of highly fractured / non-intact zones and discontinuity spacings. It should be noted that no correction for dip of the joints has been made and that the spacings shown are successive joint / core intersections within the core. The core log records and photographs are presented in Appendix 1 of the factual report and include engineering geological descriptions, details of the bedding / discontinuities and mechanical indices (TCR, SCR and RQD's) for each core run.

A Groundwater monitoring standpipe was installed in RC001. The standpipes consisted of 50mm diameter HDPE pipework with proprietary 1mm slots and incorporated a pea gravel filter pack and cement / bentonite grout seal. Headwork covers were concreted in place.

Details of the soils (strata) encountered, SPT N-Values, samples recovered and chiseling durations (hard strata boring) are presented on the boring records in Appendix 2.

3.3 Trial Pits

The trial pits were undertaken using a 5 tonne tracked excavator. The pits were logged and sampled by an IGSL geotechnical engineer.

Representative disturbed bulk and environmental samples were taken as the pits were excavated, these were placed in heavy-duty polyethene bags and tubs and returned to the site laboratory for examination and laboratory testing. Environmental samples were taken as directed by the Employer's Representative and these included glass jars, a glass vial and a plastic tub.

The trial pits were backfilled with the as-dug arisings and reinstated to the satisfaction of the Employer's Representative. The trial pit logs are presented in Appendix 3 and include engineering descriptions of the soils encountered, samples recovered, groundwater strikes and stability of the pit sidewalls.

3.4 Slit Trenches

Slit trenches were excavated at locations specified by the Employer's Representative. Trenches were performed using a rubber tracked excavator and dug to a maximum depth of 1.50mbgl. The Slit Trenches were backfilled in accordance with the Department of the Environment "Guidelines for the opening, backfilling and reinstatement of trenches in public roads".

A detailed record of the depth, diameter and type of each service encountered within the trench is presented in Appendix 4. The soil profile provided on the slit trench logs describes the majority of the soils across the transverse trench. Where services have been located the material above the service and bedding material is described as Made Ground.

3.5 Infiltration Tests

One infiltration test was performed to assess the suitability of the sub-soils for dispersion of storm water through a soakaway system. The infiltration tests were performed in accordance with BRE

Digest 365 'Soakaway Design'. To obtain a measure of the infiltration rate of the sub-soils, water is poured into each test pit, and records taken of the fall in water level against time. The infiltration rate is the volume of water dispersed per unit of exposed area per unit of time, and is generally expressed as metres / minute or metres / second. Designs are based on the slowest infiltration rate, which is generally calculated from the final cycle. The final cycle soakaway test records are presented in Appendix 5.

3.6 Setting Out & Surveying

Following completion of the exploratory works, surveying was carried out using GPS and total station techniques. Co-ordinates (x, y) were measured to Irish Transverse Mercator Grid (ITM), the geographic coordinate system for Ireland with ground levels (z) established to Malin Head. The co-ordinates and ground levels are shown on the exploratory logs while the 'as-built' exploratory plans are presented in Appendix 9.

4. LABORATORY ANALYSIS

A programme of soil and rock laboratory testing has been carried out in accordance with BS 1377 and ISO 17892-9:2018. The test schedule was prepared by the Employer's Representative.

The soil laboratory testing comprised the following and the results are presented in Appendix 6:

- Moisture Content
- Atterberg Limits
- Particle Size Distribution
- Hydrometer
- Lab Shear Vanes
- 60 x 60mm shearbox

The rock laboratory testing comprised the following and the results are presented in Appendix 7:

- point load strength index

Chemical analyses were carried out on selected soil and water samples, by specialist accredited chemical laboratory, Chemtest. The chemical testing was scheduled by the Employer's Representative and the results are presented in Appendix 8.

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Appendix 1 - Cable Percussive Borehole Records